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NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* J. J. BAKKER

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WORK TRIP GENERATION MODELS IN TRANSPORTATION PLANNING

BY

© TERENCE OLIVER CLEMENT

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled WORK TRIP GENERATION MODELS IN TRANSPORTATION PLANNING submitted by TERENCE OLIVER CLEMENT in partial fulfilment of the requirements for the degree of Master of Science.

Supervisor

Stan

John

DATE April 7, 1977

ABSTRACT

The purpose of this study is to develop appropriate trip generation models for use in forecasting future travel patterns in Edmonton.

Since trip generation is the first of four components which are used sequentially to forecast future travel demand, several constraints are imposed on the form of trip generation models by the requirements of the other three components. In particular, the modal split component attempts to estimate the percentage of people who will make their trips by each of the available modes, and therefore requires that those people who have a genuine choice of travel modes be considered separately from those who are captive to a single mode of travel. The trip generation models in this study have therefore been constrained to forecast two separate groups of trip-makers: a choice group consisting of all trip-makers who have a car available in which to make their trip, and a captive group consisting of trip-makers who do not have a car available.

In addition, only peak hour work trips are considered; it is shown that in Edmonton, peak hour traffic and transit volumes constitute an appropriate basis for designing

transportation facilities. Walk trips are not considered in this study.

A review of trip generation models that have been used previously in Edmonton and elsewhere in North America shows that the majority have based their forecasting ability on variables such as population and employment; such a dependency on variables that are difficult to project is considered a major disadvantage of these models. In addition, none of the models reviewed categorized trips as being choice or captive. Nevertheless, models of this type have been verified for and calibrated to work trip data collected in Edmonton in 1971, and the trip production models have been modified to include a rational basis for splitting total trips into the choice and captive groups.

The study proposes the hypotheses that work trip productions are a direct result of residential land development and that work trip attractions are a direct result of non-residential land development. These hypotheses are tested by developing a set of models based on three categories of residential land use and five categories of non-residential land use. These models, also, are verified for and calibrated to data collected in Edmonton in 1971.

The quantities of land developed within each of the land use categories are tangible quantities that appear explicitly in the design process for new residential and non-residential areas; land use based models, therefore, do

not suffer from the dependency on variables that are difficult to project. In addition, land use information, in the form required by these land use based models, can be obtained at a very early stage, allowing proposed developments and redevelopments to be evaluated from a transportation viewpoint at a much earlier stage in the process.

Finally, the study compares the two kinds of trip generation models by simulating the forecasting process. All models are recalibrated to data corresponding to zones developed prior to 1961 and then used to forecast work trip generation levels for the zones developed between 1961 and 1971.

By comparing these forecasts with the actual values measured in 1971, it is shown that none of the models is able to predict production and attraction levels accurately. The major cause of these inaccuracies is attributed to applying the models to zones having a substantially different structure to those used during calibration, a situation which is very likely to arise in the actual forecasting process. Suggestions are made for further research into methods of overcoming this problem.

The study concludes that land use based models have several advantages for use in Edmonton over traditional population and employment based models.

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TABLE OF CONTENTS

Page

CHAPTER I: INTRODUCTION 1

The problem 1

The objective of this thesis 3

Boundaries of the research 4

Organization of the thesis 11

CHAPTER II: LITERATURE REVIEW 12

Introduction 12

The need for disaggregation 12

Trip generation models 16

Previous studies in Edmonton 17

Previous studies elsewhere 18

Summary of variables used 21

Analytical techniques 21

Summary 25

CHAPTER III: DATA REQUIREMENTS AND DATA AVAILABILITY ... 27

Introduction 27

Demographic and trip end data 27

Land use data 42

CHAPTER IV: THE CALIBRATION OF MODELS TO EDMONTON DATA . 44

Introduction 44

Calibrating trip generation models 45

Results of calibrating production models 46

Further development 49

Results of calibrating attraction models 58

Summary 59

CHAPTER V: POSSIBLE MODEL IMPROVEMENTS 61

Introduction 61

The need for improvement 61

A framework for improvement 62

A hypothesis for production models 64

Calibrating production models 66

Results of calibrating production models 69

A hypothesis for attraction models 73

Calibrating attraction models 74

Results of calibrating attraction models 74

Summary 78

CHAPTER VI: COMPARISON OF TRIP GENERATION MODELS 79

Introduction 79

The models to be compared 79

A framework for comparison 82

Method of comparison 82

Results of recalibrating models 84

The resulting production models 88

Comparison of trip production forecasts 90

The resulting attraction models 95

Comparison of trip attraction forecasts 97

Summary 102

CHAPTER VII: CONCLUSIONS AND RECOMMENDATIONS 105

REFERENCES 112

APPENDIX A: DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES 113

APPENDIX B: RECALIBRATION OF TRIP PRODUCTION MODELS TO DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961 : COMPARISON OF RESULTS 144

APPENDIX C: RECALIBRATION OF TRIP ATTRACTION MODELS TO DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961 : COMPARISON OF RESULTS 154

LIST OF TABLES

Page

TABLE 2.1 Disaggregation of trips 15

TABLE 2.2 Variables used in trip production models 22

TABLE 2.3 Variables used in trip attraction models 23

TABLE 2.4 Advantages and disadvantages of category and regression analysis techniques 26

TABLE 3.1 Percentage of 24-hour work trip productions that occur during the morning peak hour 36

TABLE 3.2 Land use categories and zoning classifications 42

TABLE 4.1 Preliminary peak hour work trip generation regression equations 47

TABLE 4.2 Simple correlation between explanatory variables 50

TABLE 4.3 Car ownership as a determinant of choice and captive trip-makers 52

TABLE 5.1 Regression equations to test the hypothesis that dwelling units, population, labour force, car ownership and work trip productions are highly correlated with residential land use development 65

TABLE 5.2 Transformed partial regression coefficients indicating characteristics implicit in residential land use categorization 72
TABLE 5.3 Regression equations to test the hypothesis that total employment, peak hour work trip attraction, peak hour choice work trip attraction and peak hour captive work trip attraction are highly correlated with non-residential land use development 75
TABLE 5.4 Characteristics implicit in non-residential land use categorization 77
TABLE 6.1 Work trip generation regression equations based on traffic zones developed prior to 1961 85
TABLE 6.2 Dwelling units, population, cars per zone and work trip production equations calibrated to residential land use data corresponding to zones developed prior to 1961 86
TABLE 6.3 Employment and work trip attraction equations calibrated to non-residential land use data corresponding to zones developed prior to 1961 87

TABLE 6.4 Comparison of total peak hour vehicular work trip productions as estimated by MODEL 1 and MODEL 2 92
TABLE 6.5 Comparison of peak hour choice vehicular work trip productions as estimated by MODEL 3 and MODEL 4 93
TABLE 6.6 Comparison of peak hour captive vehicular work trip productions as estimated by MODEL 5 and MODEL 6 94
TABLE 6.7 Comparison of total peak hour vehicular work trip attractions as estimated by MODEL 7 and MODEL 8 99
TABLE 6.8 Comparison of peak hour choice vehicular work trip attractions as estimated by MODEL 9 and MODEL 10 100
TABLE 6.9 Comparison of peak hour captive vehicular work trip attractions as estimated by MODEL 11 and MODEL 12 101

LIST OF FIGURES

Page

FIGURE 1.1 Hourly traffic volumes measured during an average week (168 hours) on 97 street north of 125 avenue 6

FIGURE 1.2 Hourly transit volumes measured during an average week (112 hours) on 97 street north of 104 avenue 7

FIGURE 2.1 Traffic districts and zones 13

FIGURE 3.1 The 1971 Civic Census questionnaire 30

FIGURE 3.2 Categorization of 24-hour work trip productions in Edmonton (1971) by mode, sex and whether choice or captive 33

FIGURE 3.3 Categorization of peak hour work trip productions in Edmonton (1971) by mode, sex and whether choice or captive 34

FIGURE 3.4 Population density in persons per acre by traffic zone (1971) 39

FIGURE 3.5 Distribution of cars per dwelling by traffic zone (1971) 40

FIGURE 3.6 Employment density in persons per acre by traffic zone (1971) 41

FIGURE 4.1 Peak hour vehicular work trip productions vs population per traffic zone 54

FIGURE 4.2 Choice fraction of total peak hour vehicular work trip productions vs cars per dwelling 55

FIGURE 4.3 Choice fraction of total peak hour vehicular work trip productions vs cars per dwelling: alternative mathematical representation 57

FIGURE 5.1 Simplified relationship between various measures of economic activity 63

FIGURE 5.2 Surveyed population per zone vs population estimated from regression equation involving residential land use categories 67

FIGURE 5.3 Surveyed cars per zone vs cars per zone estimated from regression equation involving residential land use categories ... 68

FIGURE 5.4 Surveyed peak hour choice production vs production estimated from regression equation involving residential land use categories 70

FIGURE 6.1 Zones developed prior to 1961 83

CHAPTER I

INTRODUCTION

The problem

There are few large cities which are not experiencing increasing difficulty in coping with the demand for urban travel. Part of the continuing problem is that most cities have limited funds available for investment in new and improved transportation facilities and few have developed easy methods of confidently deciding which facilities should be improved or added to the existing system in order to maximize the benefits from their limited investments.

The problem is further complicated in that it takes upwards of five years to fully implement a major new facility. This is the time required for detailed design, land acquisition and construction and over such a period of time travel patterns can change sufficiently to render the new facility inadequate or, conversely, redundant.

It follows that transportation agencies must concern themselves not only with identifying and overcoming immediate transportation problems but also with developing techniques for forecasting probable changes in the demand for transportation during subsequent periods of time. In this way

(i) both short-term and long-term needs for new and improved facilities can be determined

(ii) priorities can be set more easily since the above information allows a greater appreciation of the implications of providing, postponing or not providing a particular facility and

(iii) decisions can be made with sufficient lead time to efficiently avert many transportation problems as opposed to inefficiently reacting to their occurrence.

The first major urban transportation study of significance to follow such an approach was conducted in Detroit in 1953 (DICKEY, 1975) and since then almost every transportation study has employed the same basic strategy which consists of the following four phases: (i) inventory (ii) analysis (iii) forecast and (iv) evaluation. This thesis is concerned with the forecasting phase of what is now known as the transportation planning process.

The process normally used to forecast travel demand comprises four components which collectively predict the number of trips within each trip purpose that will be made by each available mode on each available route during different time periods of the day. These four components are:

(i) trip generation - which estimates the production and attraction of trips within each traffic zone

(ii) trip distribution - which estimates the interchange of trips between each pair of traffic zones

(iii) modal split - which estimates how trips between each pair of zones will be split among the available modes of travel and

(iv) trip assignment - which estimates how the trips within each mode will be assigned to the available routes.

Each component consists of a set of mathematical equations or computational processes known as models and each of these models attempts to describe one or more of the many dimensions of urban travel in terms of factors that can be projected directly and easily to points in the future. Normally, such models are formulated, verified and calibrated to data collected in the field during the base year and, on the assumption that the relationships contained in the models remain stable over time, are used to project travel patterns to the design year by entering projected values of the explanatory factors.

The objective of this thesis

The objective of this thesis is to develop appropriate trip generation models for use in forecasting future travel patterns in Edmonton.

The following constraints were set up as guidelines for the work:

(i) the models should be shown to have equal or superior performance to the kinds of models that have been employed previously;

(ii) the models should be restricted in their formulation to explanatory factors

(a) for which data are readily available or easily collected in Edmonton;

(b) which have both a logical and a statistical justification for being included;

(c) which can be determined for future points in time more easily than those variables they are attempting to explain.

Boundaries of the research

Many kinds of trips make up the total demand for travel within an urban area such as work trips, school trips, shopping trips, business trips, social trips, medical trips and recreational trips. Trips within each of these categories make different demands on a transportation system and the peak demand within each category occurs at different times of the day. Consequently the total demand for travel changes considerably from hour to hour within each day as well as from weekday to weekend and from one season to another.

The most consistent heavy demand on a transportation system occurs during the morning and afternoon peak hours of each weekday. In Edmonton it has been found that traffic and transit volumes during an average weekday morning peak hour are exceeded approximately 10 percent of the time during the course of an average week (City of Edmonton Transportation Planning Branch, 1976). FIGURES 1.1 and 1.2 illustrate this point. In other words a transportation system designed to handle the weekday morning peak hour travel demand will efficiently handle the total demand for travel more than 90 percent of the time. Hence projected morning peak hour volumes constitute an appropriate basis for the design of transportation facilities in Edmonton.

Work trips make up approximately 80 percent of all automobile trips and close to 100 percent of all transit trips that occur during the morning peak hour; it is estimated that work trips, which in this study include trips made by students to places of higher education, constitute 85% of morning peak hour trips made by all modes for all purposes (City of Edmonton Transportation Planning Branch, 1976). In addition, the work trip is the most habitual of all trips and also the most inelastic, two qualities which allow work trips to be modeled more accurately than trips made for any other purpose.

The above reasoning leads to the first boundary of this

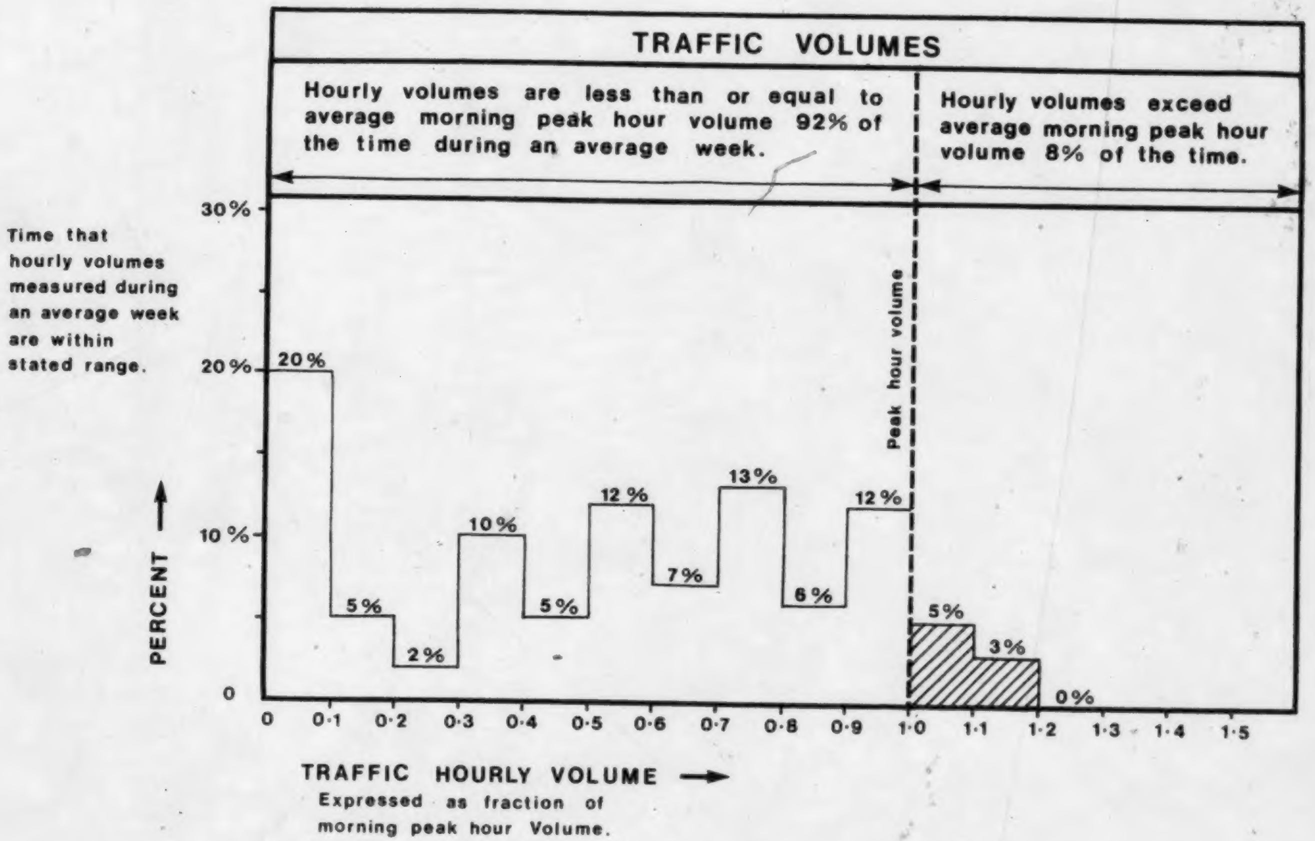


FIGURE 1.1 Hourly Traffic Volumes measured during an average week (168 hours) on 97 street north of 125 avenue.

SOURCE: The City of Edmonton Transportation Planning Branch (1976)

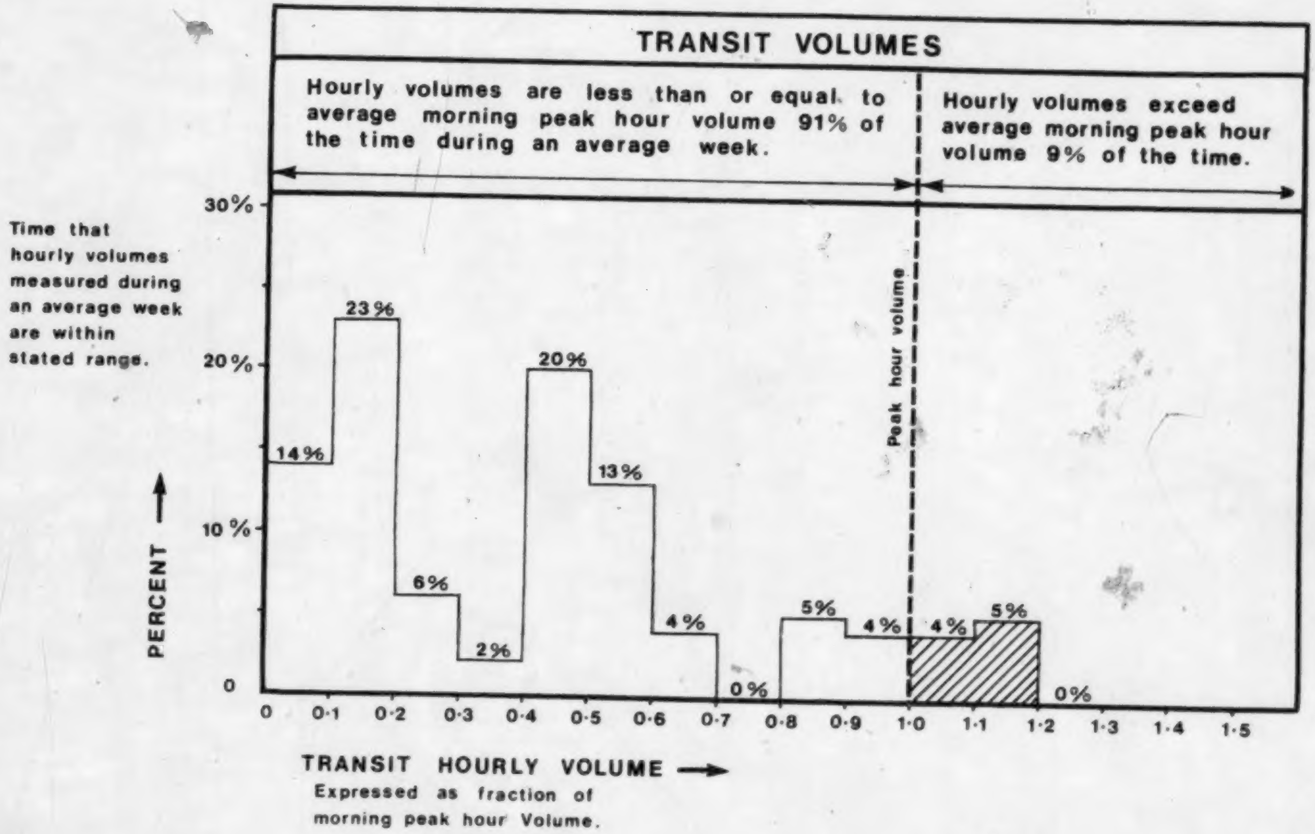


FIGURE 1.2 Hourly Transit Volumes measured during an average week (112 hours) on 97 street north of 104 avenue.

SOURCE: The City of Edmonton Transportation Planning Branch (1976) research:

> 'The effort of predicting travel demand for the purpose of designing transportation facilities in Edmonton will be concentrated on the prediction of peak hour home to work trips.'

The modal split component of the forecasting phase estimates how the trips between each pair of zones will be split among the available modes of travel. Many transportation studies have considered only the auto-driver and transit passenger modes; auto-passengers are indirectly taken into account by considering vehicle trips rather than person trips, and walk trips are ignored on a zone to zone basis on the assumption that the heaviest pedestrian volumes will occur at the concentrated destinations of trips made by other modes. Consequently, most modal split models have been developed to split trips into auto-driver trips and transit trips and have based this prediction on the comparative cost of making the trip by each of these two modes.

The implicit assumption in this methodology is that all trip-makers have the choice of making their trips by automobile or by transit, an assumption which is rarely justified. In Edmonton, it is current policy to service all areas of the City with public transportation (City of Edmonton Transportation Planning Branch, 1974a), the exceptions to this policy being new subdivisions, both residential and industrial, while in the early stages of development. In most North American cities a similar policy does not exist so that many trip-makers do not have the option of traveling by transit. The option of making a trip as an auto-driver depends on the availability of an automobile and on the possession of a valid driver's license. It is reasonable to assume that a person owning an automobile also has a valid license to drive, but it is not a reasonable assumption that every trip-maker has an automobile.

In many cities, then, there are four categories of trip-makers:

(i) those who have a choice of traveling by automobile or by transit
(ii) those who are captive to the transit mode
(iii) those who are captive to the auto-driver mode
(iv) those who are captive to the auto-passenger mode

In the City of Edmonton, because of the current policy of servicing all developed areas by transit, the third category is insignificant; it includes only those people who live in partially developed residential areas and those who work in partially developed employment zones. In addition, auto-passengers cannot be considered truly captive to this mode; in the event that the driver of the car in which they are a passenger changes mode, they too must change mode and it would seem logical that their change would be to transit as a captive transit passenger. Auto-passengers, then, can be considered as captive transit riders who are temporarily traveling as passengers in other trip-makers' automobiles.

The above reasoning leads to the second boundary of this research:

> 'Only trips made by automobile, as the driver or as a passenger, and trips made by transit will be considered in the trip generation models that are to be developed. All trip-makers will be assumed to have the option of making their trips by transit. However, trip-makers who have a car available for their trips, and thus have a genuine choice of traveling by automobile or by transit, will be considered separately from those who do not have a car available and are therefore captive to the transit mode. Auto-passengers will be assumed to have no car available and will be considered as captive transit riders who are temporarily making their trips as passengers in other trip-makers' cars. Walk trips will be ignored on a zone to zone basis on the assumption that the heaviest pedestrian volumes will occur at the concentrated destinations of trips made by automobile and public transportation, and that pedestrian problems are better treated as terminal design problems rather than network ones.'

Organization of the thesis

Chapter II reviews the kinds of trip generation models that have been employed previously in Edmonton and elsewhere in North America.

Chapter III summarizes the data requirements of such models and presents data that are available in Edmonton.

Chapter IV discusses the suitability for use in Edmonton of previously employed models and presents the results of calibrating such models to Edmonton data.

Chapter V proposes a hypothesis for a different kind of trip generation model and presents the results of calibrating models of this kind to Edmonton data.

Chapter VI compares the performance of all models calibrated.

Chapter VII presents the conclusions and recommendations arising from this research.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter reviews the kinds of trip generation models that have been employed in previous transportation studies in Edmonton and elsewhere in North America.

To facilitate analysis of travel patterns and trends, and their subsequent use in forecasting future travel demand, transportation study areas are usually divided into several sub-areas which in this report are referred to as traffic zones. FIGURE 2.1 maps the traffic zones that are being used in Edmonton; approximately 300 zones cover the presently developed area of the City.

The need for disaggregation

Chapter I discussed the boundaries of this research in terms of the kinds of trips that are being considered. Trips can be categorized by the type of trip-maker, by the mode of travel, by the time of day that the trip takes place and by the purpose of the trip. The selected categories define the level of disaggregation at which all the models must be

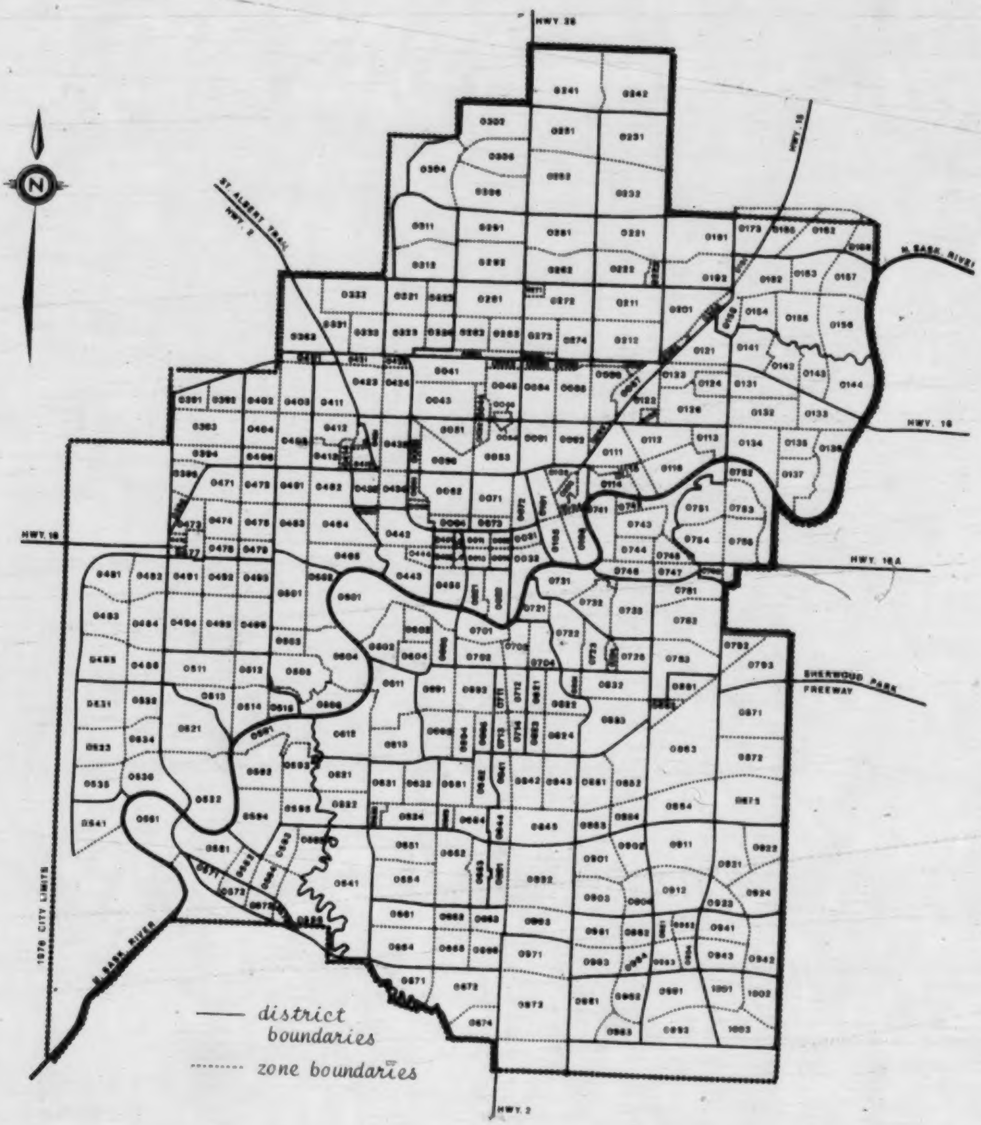

HWY. 28
HWY. 15
ST. ALBERT TRAIL
HWY. 2
N. SASK. RIVER
HWY. 16
HWY. 16
HWY. 16A
SHERWOOD PARK FREEWAY
1976 CITY LIMITS
N. SASK. RIVER
HWY. 2
N
district boundaries
zone boundaries

FIGURE 2.1: TRAFFIC DISTRICTS AND ZONES

designed to operate. Disaggregation can be viewed as a compromise as explained in the following paragraphs.

Models attempt to simulate reality and to do this exactly they must include all factors that influence the real-world situation that is being modeled. This task is usually difficult, often impractical and sometimes impossible. Transportation models attempt to simulate individual trip-making behaviour and the models described in this thesis attempt to do so on a collective basis. This presents an immediate conflict since all people do not react identically in a given situation.

'Disaggregate models' treat each trip-maker individually, an approach which is relatively new in the field of transportation modeling and which appears to hold considerable promise. However, the data requirements for 'disaggregate models' are extensive and the difficulty of forecasting such data to future time periods presents a problem which has yet to be resolved.

Disaggregating the total trip-making population into several groups of trip-makers who have some rational basis for making similar travel-related decisions thus provides a compromise between treating all people as being the same and treating each person individually. It allows a different model to be developed for each group of trip-makers. TABLE 2.1 summarizes the level of disaggregation selected for the models being considered in this thesis.

TABLE 2.1

DISAGGREGATION OF TRIPS

PERSON TYPE	CHOICE (CAR AVAILABLE)	CAPTIVE (NO CAR AVAILABLE)
MODE OF TRAVEL	AUTO-DRIVER TRANSIT RIDER	AUTO-PASSENGER TRANSIT RIDER
TIME OF TRAVEL	MORNING PEAK HOUR : 7.30AM TO 8.30AM (BASED ON WORK START TIME)	
PURPOSE OF TRIP	HOME TO WORK (OR TO HIGHER EDUCATION FACILITY)	

Essentially, two groups of trip-makers are being considered out of the many groups that make up the total trip-making population. Both groups include only vehicular work trips made during the morning peak hour. Vehicular work trips are those made by automobile, either as the driver or as a passenger, and those made by public transportation. The first group, however, contains those trip-makers who have a car available in which to make their trip, whereas the second group contains those who do not have the availability of a car. The first group is referred to as a choice group since they have a genuine choice of making their trips by automobile or by public transportation. The second group is referred to as a captive group since, in most cases, they are captive to the public transportation system.

Trip generation models

Trip generation is the first of the four components used to forecast the demand for travel. Trip generation models estimate the production and attraction of trips within each traffic zone.

There is some confusion over the definitions of the terms production and attraction. In this thesis, which deals with morning peak hour home-to-work trips only, production is defined as the number of morning peak hour vehicular work trips, within each group, that originate in a traffic zone, and attraction is defined as the number of morning peak hour vehicular work trips that terminate in a traffic zone. Production is associated with residential activity and attraction is associated with employment activity.

Many other transportation studies deal in terms of 24-hour trips, rather than peak hour trips, and during such a time period most trips have gone their full cycle. For example, a home-to-work trip has led to a work-to-home trip, the trip-maker having gone from home to work and back home again. These studies maintain the association between trip production and residential activity and between trip attraction and employment activity but do so at the expense of a clear definition of the two terms: a trip production can be either the origin or the destination of a trip as can a trip attraction, implying that characteristics, such as travel time, associated with traveling from point A to point B are identical to those associated with traveling from point B to point A.

This difference in terminology creates a minor problem when comparing trip generation models that have been used in various studies. Other studies are therefore reviewed only for the kinds of zonal factors employed in trip generation models and the methods by which these models have been formulated.

Previous studies in Edmonton

The only previous transportation study to be conducted in Edmonton is the Metropolitan Edmonton Transportation Study (Edmonton District Planning Commission, 1963). This study projected 24-hour trips and factored the resulting daily traffic volumes to peak hour volumes. The analysis portion of this study concluded that in 1961 the amount of travel generated by a family was strongly related to the income level of the family: when income was high the daily trips were numerous and when income was low the daily trips were few in number. Automobile ownership and income level were found to be strongly related and since more current information was available on the former it was used in place of income level for the projection of trip production. Trip production was based on hand fitted curves of person trips per family versus automobile ownership, and trip attraction was based on the employment level in each zone. Special attention was given to major employment centres such as the central business district, the Government centre and the University of Alberta.

Previous studies elsewhere

The Regional Municipality of Ottawa-Carleton Planning Department (1973) tested 'hundreds of trip generation relationships'. Trips were disaggregated by purpose but not by time of day or type of person. Three work trip production equations were developed corresponding to three ranges of a work participation ratio; each equation expressed trip production as a fraction of zonal population. Work trip attraction was related directly to total employment.

Voorhees and Associates (1967), in a study undertaken for the Washington Metropolitan Area Transit Authority, reported that regression analysis was used to test relationships between work trip generation and various combinations of variables such as automobile ownership, population, dwelling units, labour force and employment. However, the equations selected for use in the study related work trip production to the single variable of labour force and work trip attraction to the single variable of total employment. Different generation equations were developed for zones within the District of Columbia and for zones outside of this central area.

Sachdev and Leonhardt (1972), in a major update of the

Puget Sound regional transportation plans, employed the cross-classification (category analysis) method to develop trip generation rates for nine trip purposes in terms of various classifications of socio-economic and land use characteristics that can be used to describe activity within an urban area.

Trip production was related to two groups of variables: (i) household characteristics and (ii) environmental characteristics. Household characteristics were subdivided into average household size, median income of head of household and automobiles owned per household. Environmental characteristics included net residential density and gross residential density. By using 12 categories of household size, 12 levels of car ownership, 14 income levels, 10 ranges of net residential density and 10 ranges of gross residential density, 201,600 distinct combinations resulted with which to categorize a particular household. Through a process of grouping, these 201,600 categories were reduced to 21 classes, resulting from 7 groups of household characteristics cross-classified with 3 groups of environmental characteristics. A trip production rate was calculated for these 21 classes for each of the nine trip purposes.

Trip attraction was related to four activity measures: (i) total population (ii) total employment (iii) retail employment and (iv) school enrollment. Work trip attraction was expressed in terms of total employment only. Seven attraction groups were formed to reflect geographic differences in the region and an attraction rate was calculated for each group.

The Trip Generation Project Committee (1974) carried out an excellent and enlightening review of trip generation analysis procedures used in Canadian urban transportation planning studies. Eleven Canadian cities contributed information on trip production and attraction models developed prior to 1971. The Committee found that all studies had employed either category analysis or regression analysis techniques to calibrate trip generation models but considered that many studies had incorrectly applied the techniques of multiple linear regression by including, in the same equation, two or more explanatory variables that were not truly independent of each other. In the Committee's opinion, the most frequent violation of this basic principle of regression analysis occurred in the formulation of trip production equations in which variables such as population, dwelling units and car ownership, all of which are measures of residential activity in a zone and thus highly colinear, were included in the same regression equation.

In addition, the Committee noted that some other equations were irrationally formulated. In particular, measures of residential activity, such as population and car ownership, had been included in equations for estimating the number of work trips attracted to a zone.

Summary of variables used

TABLES 2.2 and 2.3 have been compiled, using data from the studies mentioned previously, as a summary of the variables that have been used in work trip production and attraction equations. They also indicate the analytical technique that was employed in the development of each equation.

A variety of variables has been used to explain trip production including basic variables such as population and dwelling units through to composite variables such as labour force multiplied by a non-transit index divided by car occupancy.

The majority of trip attraction equations have used total employment as a single independent variable although some studies have disaggregated total employment into retail, office and other such employment categories and utilized these instead of the total employment figure.

Analytical techniques

With the exception of the Metropolitan Edmonton Transportation Study, all of the studies employed linear regression analysis or category analysis techniques in the development of trip generation models. The two techniques

TABLE 2.2

VARIABLES USED IN TRIP PRODUCTION MODELS

[1] R=linear regression
H=hand fitted curves
C=category analysis
U=unknown

[2] Z=trips produced per zone
H=trips produced per household

	TRANSPORTATION STUDY																	
INDEPENDENT VARIABLE	VANCOUVER	WINNIPEG	TORONTO MTARTS	VICTORIA	GALT	CORNWALL	BURLINGTON	HAMILTON	ORILLIA	CALGARY	BRANDON	TORONTO TARMS	EDMONTON 1963	OTTAWA/CARLETON	WASHINGTON D.C.	PUGET SOUND	CALGARY	TORONTO TARMS
POPULATION (ZONAL)			X	X	X	X	X	X		X		X		X				
DWELLING UNITS		X	X		X	X	X	X	X			X						
CARS (ZONAL)			X		X		X											
POPULATION PER DWELLING UNIT																X	X	X
CARS PER DWELLING UNIT													X			X	X	X
DWELLING UNITS WITH CARS	X																	
DWELLING UNITS WITH CARS * TIME FROM CBD	X																	
TRAVEL TIME FROM CBD	X																	
LABOUR FORCE															X			
LABOUR FORCE*NON-TRANSIT INDEX/CAR OCCUPANCY											X							
LABOUR FORCE/POPULATION														X				
MEDIAN INCOME OF HEAD OF HOUSEHOLD																X		
NET RESIDENTIAL DENSITY																X		
GROSS RESIDENTIAL DENSITY																X		X
ANALYTICAL TECHNIQUE EMPLOYED[1]	R	R	R	R	R	R	R	R	R	R	U	R	H	U	R	C	C	C
DEPENDENT VARIABLE[2]	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	H	Z	Z	H	H	H

TABLE 2.3

VARIABLES USED IN TRIP ATTRACTION MODELS

	TRANSPORTATION STUDY															
INDEPENDENT VARIABLE	VANCOUVER	WINNIPEG	TORONTO MTARTS	VICTORIA	GALT	CORNWALL	BURLINGTON	HAMILTON	ORILLIA	CALGARY	BRANDON	TORONTO TARMS	EDMONTON 1963	OTTAWA/CARLETON	WASHINGTON D.C.	PUGET SOUND
TOTAL EMPLOYMENT	X				X	X	X	X	X	X			X	X	X	X
WHOLESALE EMPLOYMENT			X									X				
WAREHOUSE EMPLOYMENT		X														
RETAIL EMPLOYMENT		X	X	X								X				
OFFICE EMPLOYMENT		X	X													
MANUFACTURING EMPLOYMENT		X	X	X								X				
SERVICE EMPLOYMENT		X										X				
CONSTRUCTION EMPLOYMENT			X													
COMMERCIAL EMPLOYMENT						X										
PUBLIC INSTITUTION EMPLOYMENT		X														
OTHER EMPLOYMENT			X	X								X				
TOTAL EMPLOYMENT*TRANSIT FACTOR											X					
COMMERCIAL AREA				X												
INDUSTRIAL AREA				X												
POPULATION			X	X												
CAR OWNERSHIP				X												
RESIDENTIAL AREA				X												
ANALYTICAL TECHNIQUE EMPLOYED[1]	R	R	R	R	R	R	R	U	R	R	R	R	U	U	R	C
DEPENDENT VARIABLE	TRIPS ATTRACTED PER ZONE															

[1] R=linear regression
C=category analysis
U=unknown

are similar to the extent that they both assume that there is a response in the number of trips generated (dependent variable) that can be explained by the levels of a number of other factors (independent variables).

Linear regression analysis assumes that this response surface can be represented by a linear function of the independent variables and identifies this function such that the sum of the squares of the deviations between the observations and the estimated response surface is minimized. The resulting function, or regression equation, is continuous which allows easy estimation of the response level for values of the independent variables other than those that were used initially to determine the function. The potential danger lies in the ease with which the equation can be used unknowingly beyond its limitations.

Category analysis subdivides the observations into several categories according to the levels of the various independent variables being considered and an average response level is calculated for each of the resulting categories. For example, if trip production was related to household size and income level, there might be six levels of household size ranging from one person to six or more persons per household and possibly six levels of income ranging from zero to $30,000 and over in $6,000 increments. An average trip production level could be calculated for households falling into each of the 36 categories (6 household sizes cross-classified with 6 income levels). Category analysis, therefore, does not assume the response surface to be a linear or any other specific function of the independent variables; it merely attempts to describe a set of points that are known to lie on this surface.

TABLE 2.4 presents some of the advantages and disadvantages of these two techniques and Douglas (1973) provides a practical comparison of their application in developing trip generation models.

Summary

The foregoing section has reviewed the kinds of trip generation models that have been employed previously in Edmonton and elsewhere in North America. None of the models reviewed has categorized trips according to whether or not the trip-maker has a choice of travel modes and as such they may not be capable of satisfying the constraints imposed upon the development of models within this thesis. Nevertheless, models of these types have been calibrated to Edmonton data and the results presented in Chapter IV.

TABLE 2.4

ADVANTAGES AND DISADVANTAGES OF CATEGORY AND REGRESSION ANALYSIS TECHNIQUES

	ADVANTAGES	DISADVANTAGES
CATEGORY ANALYSIS	1. Makes no assumption about the form of function. 2. The resulting model cannot be used unknowingly beyond its limitations. 3. Colinearity of independent variables does not affect the model (but does increase the difficulty of categorization).	1. Requires extensive data to ensure a reasonable sample within each category. 2. Does not provide information on the importance of the independent variables nor on the statistical significance of the model.
REGRESSION ANALYSIS	1. Different relationships involving different independent variables can be tested quickly and easily. 2. Requires less extensive data. 3. Determines the relative importance of the independent variables. 4. Provides statistical measures of the significance of the partial regression coefficients and of the overall significance of the regression equation.	1. Assumes (and forces) the regression equation to be a linear function of the independent variables although individual variables can be transformed to some non-linear form. 2. The resulting model can be very easily (and dangerously) applied beyond its limitations. 3. Independent variables should be truly independent. Colinearity can render the model invalid.

CHAPTER III

DATA REQUIREMENTS AND DATA AVAILABILITY

Introduction

Chapter II discussed the kinds of trip generation models that have been employed previously in Edmonton and elsewhere in North America and TABLES 2.2 and 2.3 have summarized the variables that have been used in developing trip production and trip attraction models. This Chapter presents the data that are available in Edmonton for developing trip generation models of these and other types. The data fall into two categories:

(i) demographic and trip end data

(ii) land use data

Demographic and trip end data

The demographic and trip end data include, on a traffic zone basis, details of the following variables:

(i) population

(ii) dwelling units

(iii) cars (includes all vehicles available for the home to work trip)

(iv) employed labour force (which constitutes approximately 97% of the total labour force)

(v) employment

(vi) total peak hour vehicular work trip production

(vii) peak hour choice vehicular work trip production

(viii) peak hour captive vehicular work trip production

(ix) total peak hour vehicular work trip attraction

(x) peak hour choice vehicular work trip attraction

(xi) peak hour captive vehicular work trip attraction.

The source of these data is the 1971 Edmonton Civic Census (City of Edmonton Transportation Planning Branch, 1974b). In 1971, four questions were added to the normal annual census questionnaire for the specific purpose of analyzing work trip travel patterns. These additional questions were:

(i) are you (a) employed?
(b) a housewife?
(c) a student?
(d) retired?
(e) unemployed?

And if employed or a student:

(ii) what is the address of your place of work or study?

(iii) how do you travel to your place of work or study?

(a) as an auto-driver?

(b) as an auto-passenger?

(c) by transit?

(d) by walking?

(e) by some other mode?

(iv) what time do you start work or study?

FIGURE 3.1 shows the full questionnaire that was used in 1971.

Approximately 130,000 of these questionnaires were completed by home interview and details of more than 435,000 persons living within the City of Edmonton were collected. This represents a survey sample of as close to 100 percent as is practicable.

Approximately 167,000 people reported making a trip to work or to a place of study on the survey day, and of these:

(i) 97,000 (58.2%) made their trips as auto-drivers;

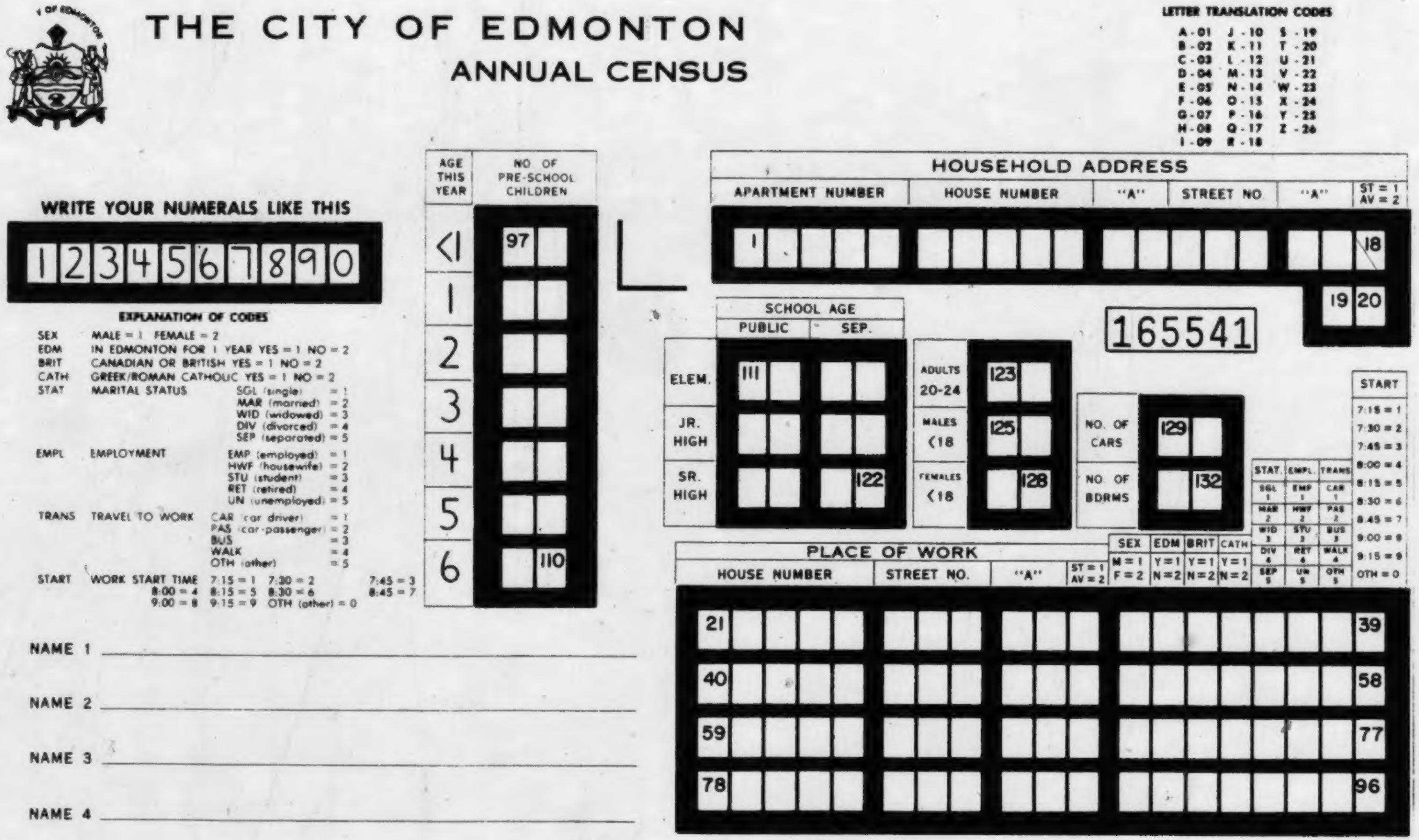
(ii) 14,000 (8.3%) made their trips as auto-passengers;

(iii) 32,000 (19.3%) made their trips by transit;

(iv) 17,000 (9.9%) walked to work;

(v) 7,000 (4.3%) made their trips by some other mode.

Of these trips, 88,000 (52.5%) were made during the morning peak hour which in this study is defined as being from 7.30am to 8.30am, based on work starting time.



THE CITY OF EDMONTON
ANNUAL CENSUS

LETTER TRANSLATION CODES

A - 01	J - 10	S - 19
B - 02	K - 11	T - 20
C - 03	L - 12	U - 21
D - 04	M - 13	V - 22
E - 05	N - 14	W - 23
F - 06	O - 15	X - 24
G - 07	P - 16	Y - 25
H - 08	Q - 17	Z - 26
I - 09	R - 18	

WRITE YOUR NUMERALS LIKE THIS

1 2 3 4 5 6 7 8 9 0

EXPLANATION OF CODES

SEX MALE = 1 FEMALE = 2
EDM IN EDMONTON FOR 1 YEAR YES = 1 NO = 2
BRIT CANADIAN OR BRITISH YES = 1 NO = 2
CATH GREEK/ROMAN CATHOLIC YES = 1 NO = 2
STAT MARITAL STATUS SGL (single) = 1
MAR (married) = 2
WID (widowed) = 3
DIV (divorced) = 4
SEP (separated) = 5
EMPL EMPLOYMENT EMP (employed) = 1
HWF (housewife) = 2
STU (student) = 3
RET (retired) = 4
UN (unemployed) = 5
TRANS TRAVEL TO WORK CAR (car driver) = 1
PAS (car-passenger) = 2
BUS = 3
WALK = 4
OTH (other) = 5
START WORK START TIME 7:15 = 1 7:30 = 2 7:45 = 3
8:00 = 4 8:15 = 5 8:30 = 6 8:45 = 7
9:00 = 8 9:15 = 9 OTH (other) = 0

AGE THIS YEAR	NO. OF PRE-SCHOOL CHILDREN
<1	97
1	
2	
3	
4	
5	
6	110

HOUSEHOLD ADDRESS

APARTMENT NUMBER	HOUSE NUMBER	"A"	STREET NO.	"A"	ST = 1 AV = 2
1					18
					19 20

165541

	SCHOOL AGE	
	PUBLIC	SEP.
ELEM.	111	
JR. HIGH		
SR. HIGH		122

ADULTS 20-24	123
MALES <18	125
FEMALES <18	128

NO. OF CARS	129
NO. OF BDRMS	132

STAT.	EMPL.	TRANS
SGL 1	EMP 1	CAR 1
MAR 2	HWF 2	PAS 2
WID 3	STU 3	BUS 3
DIV 4	RET 4	WALK 4
SEP 5	UN 5	OTH 5

START
7:15 = 1
7:30 = 2
7:45 = 3
8:00 = 4
8:15 = 5
8:30 = 6
8:45 = 7
9:00 = 8
9:15 = 9
OTH = 0

PLACE OF WORK

HOUSE NUMBER	STREET NO.	"A"	ST = 1 AV = 2	SEX M = 1 F = 2	EDM Y = 1 N = 2	BRIT Y = 1 N = 2	CATH Y = 1 N = 2	STAT.	EMPL.	TRANS	START
21											39
40											58
59											77
78											96

NAME 1 ______________________

NAME 2 ______________________

NAME 3 ______________________

NAME 4 ______________________

FIGURE 3.1: THE 1971 CIVIC CENSUS QUESTIONNAIRE

The survey was made primarily at the household level and consequently much of the data pertain to households rather than to individuals. Car ownership data fall into this category and created some problems when used to classify transit trips as choice or captive. The method used was as follows (City of Edmonton Transportation Planning Branch, 1975):

> 'At the household level, an automobile was first matched to each reported auto-driver work trip. Then each reported transit trip was classified as being choice if an additional automobile was available, or captive if an automobile was not available. A particular automobile was considered to be available for one transit rider only.'

The problems inherent in this method are:

(i) it was assumed that if an automobile was available for use by a transit rider then that transit rider had a valid license to drive a car;

(ii) if two or more transit trips originated in a particular household and less than this number of additional cars were available (but at least one) then, although the correct number of transit trips would be classified as choice trips, the possibility existed of classifying the wrong transit trips as being choice.

Both of these problems are partially attributable to car ownership data being collected at the household level rather than at the individual level. For example, if a transit rider owned a car then it would be reasonable to assume that this person had a license to drive it. In addition, if car ownership data were available on an individual basis there would be less confusion as to which transit trips were the choice trips. However, problems such as these are almost impossible to remove entirely in a survey of this magnitude.

Using car ownership to classify vehicular work trips as choice or captive showed that approximately 75% of all vehicular work trips fall into the choice group and the remaining 25% comprise the captive group.

FIGURES 3.2 and 3.3 show the breakdown of 24-hour work trips and peak hour work trips, respectively, by mode, sex and whether they are choice or captive. These figures show that approximately twice as many men are employed as women and whereas most men travel to work as auto-drivers, the majority of women travel by transit or as auto-passengers. It is not unexpected, therefore, that women constitute almost 70% of the captive group and only 20% of the choice group of trip-makers.

The breakdown of peak hour work trips by sex and whether choice or captive is very similar to the breakdown of 24-hour work trips; the deviation is at most 5%. This shows that the peak hour fraction is representative of the total work trip-making population. The breakdowns by mode

<table>
<tr><td colspan="7">24-HOUR WORK TRIP PRODUCTIONS BY ALL MODES 167237 TRIPS</td></tr>
<tr><td colspan="3">MALE 110208 65.9%</td><td colspan="4">FEMALE 57029 34.1%</td></tr>
<tr><td colspan="2">AUTO-DRIVER
97292
58.2%</td><td colspan="2">TRANSIT
32273
19.3%</td><td>PASS
13914
8.3%</td><td colspan="2">WALK&OTHER
23758
14.2%</td></tr>
<tr><td>MALE
80583
82.8%</td><td>FEMALE
16709
17.2%</td><td>MALE
12080
37.4%</td><td>FEMALE
20193
62.6%</td><td>M=4669
F=9245</td><td>MALE
12876
54.2%</td><td>FMALE
10882
45.8%</td></tr>
</table>

<table>
<tr><td colspan="4">WORK TRIP PRODUCTIONS BY VEHICULAR MODES 143479 TRIPS 85.8%</td></tr>
<tr><td colspan="2">MALE 97332 67.8%</td><td colspan="2">FEMALE 46147 32.2%</td></tr>
<tr><td colspan="2">CHOICE 107982
75.3%</td><td colspan="2">CAPTIVE 35497
24.7%</td></tr>
<tr><td>MALE
86397
80.0%</td><td>FEMALE
21585
20.0%</td><td>MALE
10935
30.8%</td><td>FEMALE
24562
69.2%</td></tr>
</table>

FIGURE 3.2

CATEGORIZATION OF 24-HOUR WORK TRIP PRODUCTIONS IN EDMONTON (1971) BY MODE, SEX AND WHETHER CHOICE OR CAPTIVE

<table>
<tr><td colspan="6">PEAK HOUR WORK TRIP PRODUCTIONS BY ALL MODES 87840 TRIPS</td></tr>
<tr><td colspan="3">MALE 59816 68.1%</td><td colspan="3">FEMALE 28024 31.9%</td></tr>
<tr><td colspan="2">AUTO-DRIVER
54948
62.5%</td><td colspan="2">TRANSIT
16338
18.6%</td><td>PASS
8671
9.9%</td><td>WALK &c
7883
9.0%</td></tr>
<tr><td>MALE
46573
84.8%</td><td>FEMALE
8375
15.2%</td><td>MALE
6164
37.7%</td><td>FEMALE
10174
62.3%</td><td>M=2902
F=5769</td><td>M=4177
F=3706</td></tr>
</table>

<table>
<tr><td colspan="4">WORK TRIP PRODUCTIONS BY VEHICULAR MODES 79957 TRIPS 91.0%</td></tr>
<tr><td colspan="2">MALE 55639 69.6%</td><td colspan="2">FEMALE 24318 30.4%</td></tr>
<tr><td colspan="2">CHOICE 60708
75.9%</td><td colspan="2">CAPTIVE 19249
24.1%</td></tr>
<tr><td>MALE
49986
82.3%</td><td>FEMALE
10722
17.7%</td><td>MALE
5653
29.4%</td><td>FEMALE
13596
70.6%</td></tr>
</table>

FIGURE 3.3

CATEGORIZATION OF PEAK HOUR WORK TRIP PRODUCTIONS IN EDMONTON (1971) BY MODE, SEX AND WHETHER CHOICE OR CAPTIVE show that the walk and other trips are a less important category during the peak hour than they are for work trips as a whole. TABLE 3.1 accentuates these points by expressing the number of trips within each sub-group, that occur during the peak hour, as a percentage of the 24-hour trips within that sub-group.

TABLE 3.1 shows that 52.5% of all work trips occur during the peak hour and that the corresponding percentages for most sub-groups vary only a few percentage points about this overall average. Exceptions to this are trips made as auto-passengers, walk trips and trips made by other non-specified modes. 62% of auto-passengers travel to work during the peak hour implying an auto-occupancy rate which varies from a high of 1.16 during the peak hour to a low of 1.12 during other times of the day. This higher occupancy rate during the peak hour reflects both the dependency of auto-passengers on auto-drivers and the increased opportunities that are available during the peak hour due to the concentration of auto-driver work trips.

Only 33% of walk trips and trips by other non-specified modes occur during the peak hour; the remaining 67% occur at other times of the day. This could reflect one or both of two things:

(i) that the higher level of transit service during the peak hour and especially the greater opportunities for people to travel as auto-

TABLE 3.1

PERCENTAGE OF 24-HOUR WORK TRIP PRODUCTIONS THAT OCCUR DURING THE MORNING PEAK HOUR

PRODUCTION SUB-GROUP	PEAK HOUR WORK TRIP PRODUCTIONS	24-HOUR WORK TRIP PRODUCTIONS	PERCENT OF PRODUCTIONS IN PEAK HOUR
PRODUCTIONS BY ALL MODES	87840	167237	52.5%
MALE	59816	110208	54.3%
FEMALE	28024	57029	49.1%
AUTO-DRIVER	54948	97292	56.5%
MALE	46573	80583	57.8%
FEMALE	8375	16709	50.1%
TRANSIT	16338	32273	50.6%
MALE	6164	12080	51.0%
FEMALE	10174	20193	50.4%
AUTO-PASSENGER	8671	13914	62.3%
MALE	2902	4669	62.2%
FEMALE	5769	9245	62.4%
WALK AND OTHER MODES	7883	23758	33.2%
MALE	4177	12876	32.4%
FEMALE	3706	10882	34.1%
ALL VEHICULAR MODES	79957	143479	55.7%
MALE	55639	97332	57.2%
FEMALE	24318	46147	52.7%
CHOICE PRODUCTIONS	60708	107982	56.2%
MALE	49986	86397	57.9%
FEMALE	10722	21585	49.7%
CAPTIVE PRODUCTIONS	19249	35497	54.2%
MALE	5653	10935	51.7%
FEMALE	13596	24562	55.4%

passengers are persuading many potential peak hour walk trips to travel by transit or as auto-passengers;

(ii) that the majority of walk trips are short, local trips made by people who work at local shopping centres which normally open for business sometime after the morning peak hour.

However, this thesis concentrates on trips made during the morning peak hour by the three major vehicular modes and treats them as choice or captive rather than by the specific modes of travel. FIGURES 3.2 and 3.3 and TABLE 3.1 show that peak hour vehicular work trips, when classified as choice or captive, constitute a representative sample of the total vehicular work trip-making population and that extracting the peak hour fraction for analysis does not lead to a distorted picture of trip-making patterns in Edmonton.

In a city, such as Edmonton, which has increased in population by an average of 4% per year for the past 20 years, there are always areas where new development is taking place. These areas have been excluded from the analyses described in Chapters IV and V for the following reasons:

(i) developing residential areas are, by definition, changing rapidly in terms of population and dwelling units, and demographic and trip end data collected at a certain point in time are unlikely to correspond to other data, such as the land use data described in the following section, even though both may have been collected within a few months of each other. This problem is not significant with fully developed and other established areas.

(ii) people moving into developing residential areas require several months before settling into a regular pattern of work trip-making behaviour. In addition, transit service to such areas is usually sub-standard until the area is 60 to 80 percent populated. Thus many people may not be traveling to work by their preferred mode and many auto-drivers, who in this thesis are automatically considered as choice trip-makers, may in fact be temporarily captive to the auto-driver mode.

Similar arguments apply to developing non-residential areas.

Of the 350 traffic zones shown in FIGURE 2.1 approximately 300 were reported as having some activity within them in 1971. Of these, 234 have been selected as being sufficiently developed and stable to facilitate meaningful analyses of trip generation characteristics. Appendix A contains a list of the demographic and trip end statistics for these 234 traffic zones and FIGURES 3.4, 3.5 and 3.6 show the zonal distribution of population, cars per dwelling and employment, respectively. It should be noted that since only households within the 1971 City limits were surveyed, the trip production figures quoted in Appendix A include trips destined to areas both internal and external

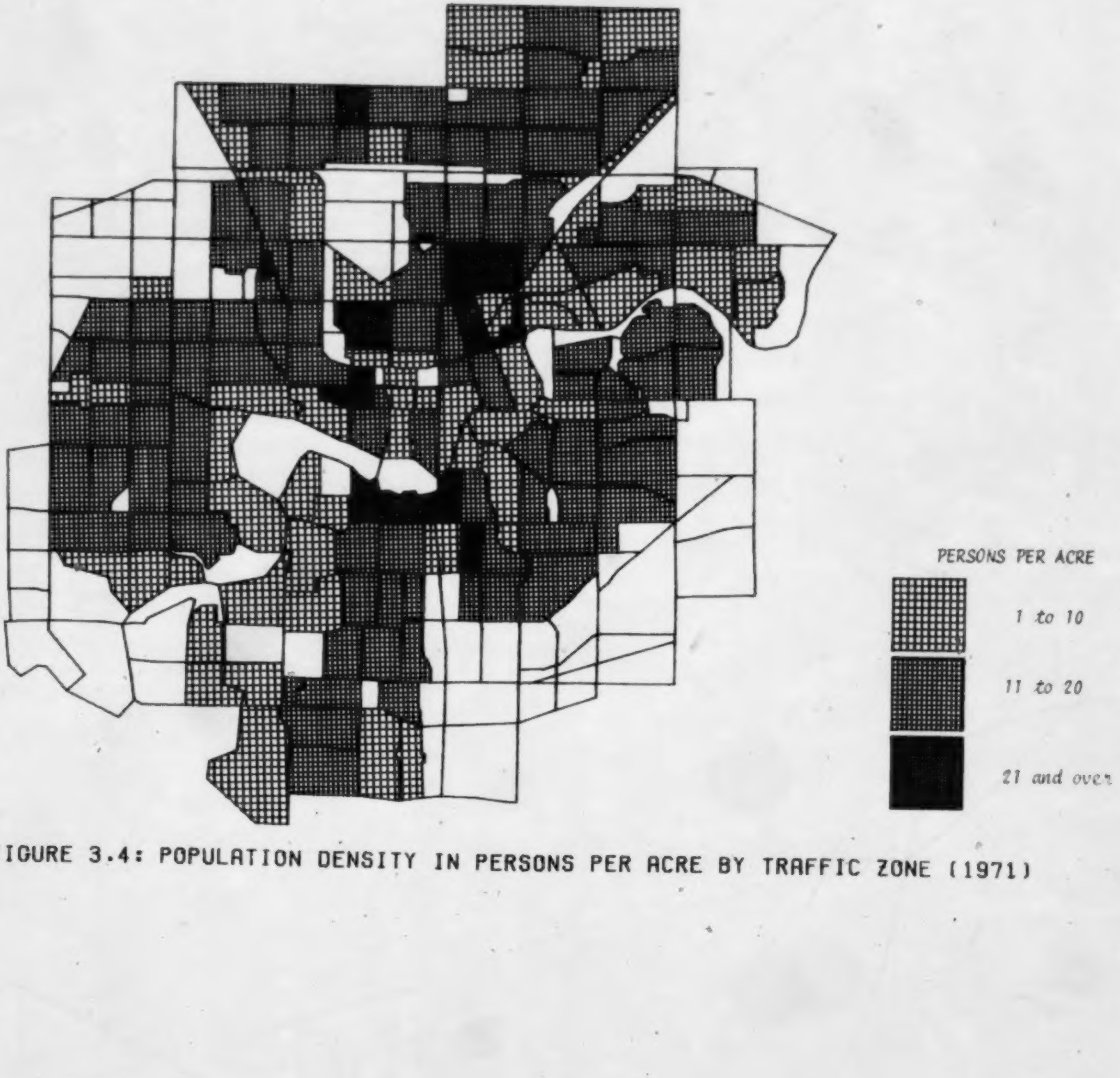

PERSONS PER ACRE
1 to 10
11 to 20
21 and over

FIGURE 3.4: POPULATION DENSITY IN PERSONS PER ACRE BY TRAFFIC ZONE (1971)

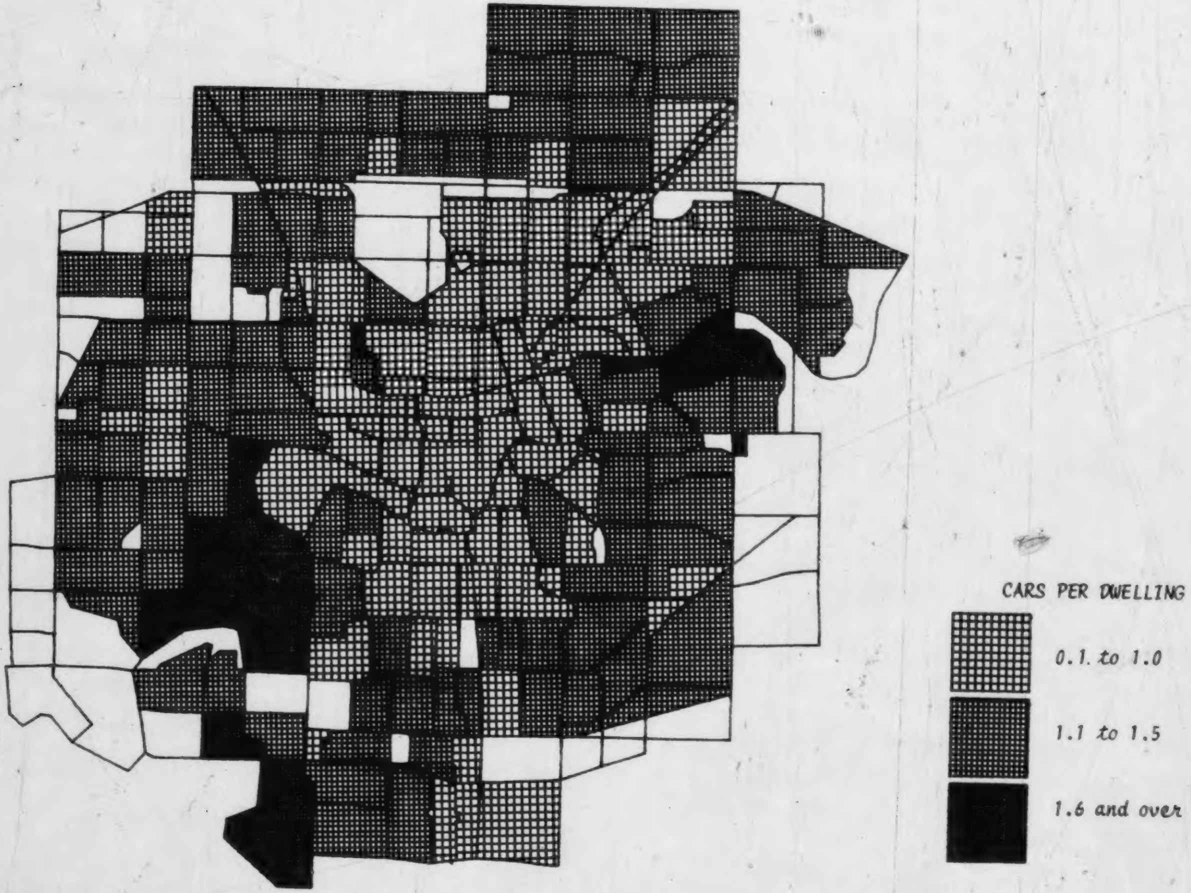

CARS PER DWELLING
0.1. to 1.0
1.1 to 1.5
1.6 and over

FIGURE 3.5: DISTRIBUTION OF CARS PER DWELLING BY TRAFFIC ZONE (1971)

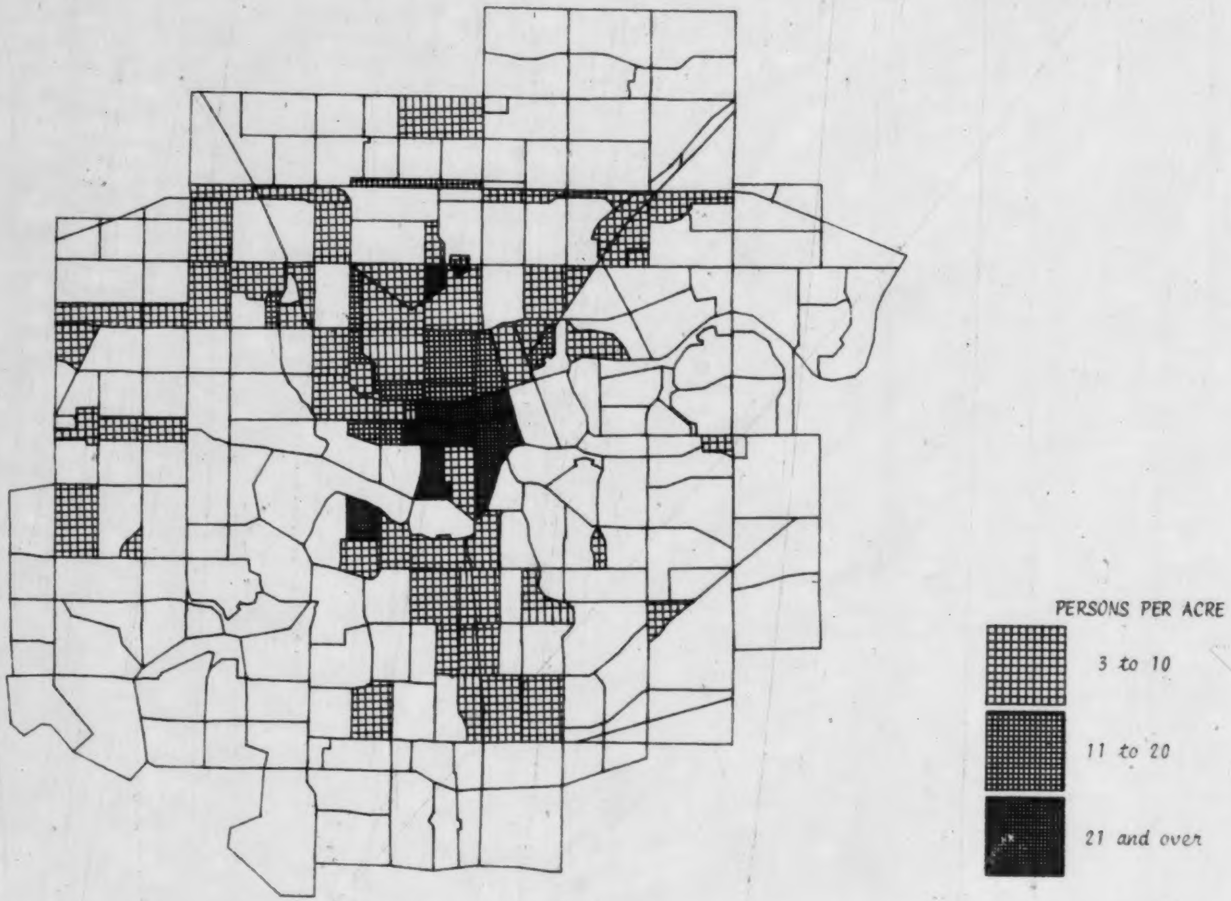

PERSONS PER ACRE
3 to 10
11 to 20
21 and over

FIGURE 3.6: EMPLOYMENT DENSITY IN PERSONS PER ACRE BY TRAFFIC ZONE (1971)

to the City, whereas the trip attraction figures include only trips that originated within the City limits. This explains the difference of 4630 trips between total productions and total attractions.

Land use data

The land use data contain the quantities, in acres, within each traffic zone of the eight land use categories listed and defined in TABLE 3.2.

TABLE 3.2

LAND USE CATEGORIES AND ZONING CLASSIFICATIONS

LAND USE CATEGORY	ZONING CLASSIFICATION[1]
LOW DENSITY RESIDENTIAL	R1,RC1,R2
MEDIUM DENSITY RESIDENTIAL	R2A,R3,R4,P3,Some R3A, Some R5
HIGH DENSITY RESIDENTIAL	R6,R7,Some R3A,Some R5 (high-rises having an elevator)
CENTRAL AREA OFFICE	C4,C6,Some C5,CC
UNIVERSITY-COLLEGE	Higher education facilities
INDUSTRIAL	M1,M2,M3
COMMERCIAL	C1,C2,C2A,C3,Some C5,C7,C8,C9
INSTITUTIONAL	P1,P2,MA

[1] For a detailed explanation of zoning classifications see the City of Edmonton (1970).

The source of the land use data is the Population and Land Use System maintained by the City of Edmonton Planning Department. The data correspond to December, 1971.

Appendix A contains a list of the land use data for the 234 traffic zones selected for analysis of trip generation characteristics but it should be noted that the City of Edmonton Planning Department advised of possible inaccuracies in these data. Unfortunately, these are the only data of this kind currently available and for this thesis must suffice for the testing of hypotheses presented in Chapter V.

CHAPTER IV

THE CALIBRATION OF MODELS TO EDMONTON DATA

Introduction

In this chapter, trip generation models, similar to those that have been used elsewhere, are verified for and calibrated to 1971 Edmonton data. These models will be referred to as population and employment based models to differentiate them from the land use based models introduced in Chapter V.

One of the constraints on the models developed in this thesis is that tripmakers should be categorized into two groups: (i) those who have a car available in which to make their work trip and thus have a genuine choice of travel modes to work and (ii) those who do not have a car available for their work trip. These two groups are referred to as a choice group and a captive group respectively.

In this thesis, the captive group includes those people who travel to work as auto-passengers since they are assumed to have no car available. It can be argued that these people are not strictly captive since they still retain the option of traveling to work by transit. However, auto-passengers are considered not to have complete control over their mode selection since in the event that the driver of the car, in which they are a passenger, changes mode then they too must change mode. As explained in Chapter I, auto-passengers are considered as captive transit riders who are temporarily traveling as passengers in other tripmakers' cars.

A variety of trip generation models have been employed elsewhere. Chapter II describes some of these models and TABLES 2.2 and 2.3 summarize the independent variables that have been used. Several of these models were considered statistically invalid due to inclusion of colinear variables. Of the remainder, some include variables for which data are not available in Edmonton.

Calibrating trip generation models

It will be noted that all trip generation models presented in this and subsequent Chapters have been developed using the technique of multiple linear regression analysis. As discussed in Chapter II, and summarized in TABLE 2.4, regression analysis affords considerably more flexibility than category analysis in exploratory work such as trip generation modeling. It should not be inferred that inferior models would result from category analysis but only that within the time constraints of this thesis regression analysis techniques allow many more relationships to be investigated and tested.

The following four statistical indicators have been used to determine the significance of regression equations:

(i) the t-statistic, which is a measure of the individual significance of the partial regression coefficients;

(ii) the coefficient of determination, (R^2), which is the fraction of the total variance in the dependent variable that is explained by the regression equation;

(iii) the F-statistic, which gives an overall measure of the significance of the regression equation, and

(iv) the standard error of estimate, which is the standard deviation of the dependent variable about the regression plane.

Standard tables, as found in Neville and Kennedy (1966), list the critical values of these statistics for various levels of significance and degrees of freedom (DF).

TABLE 4.1 presents the models that have been tested and includes the resulting coefficients together with the corresponding indicators of statistical significance.

Results of calibrating production models

Population per zone would appear to be an excellent indicator of peak hour work trip production ($R^2=0.914$, $t=49.6$, $DF=232$) and appears also to model peak hour choice work trip production well ($R^2=0.910$, $t=48.5$). This latter

TABLE 4.1

PRELIMINARY PEAK HOUR WORK TRIP GENERATION REGRESSION EQUATIONS

DEPENDENT VARIABLE	INTERCEPT	COEFF	INDEPENDENT VAPIABLE	DF	R²	t	, sig	error	F	,sig
TOTAL PRODUCTION PER ZONE mean=322.18 std.dev=321.24	= -2.02441	+0.17685*	POPULATION PER ZONE	232	0.914	49.6	.001	94.4	2464	.01
	= 16.19336	+0.54571*	DWELLINGS PER ZONE	232	0.862	38.0	.001	119.8	1444	.01
	= -4.37988	+0.53132*	CARS PER ZONE	232	0.952	67.8	.001	70.5	4600	.01
	= 19.05444	+0.45831*	LABOUR FORCE PER ZONE	232	0.902	46.1	.001	101.0	2126	.01
CHOICE PRODUCTION PER ZONE mean=243.66 std.dev=242.31	= -0.37669	+0.13312*	POPULATION PER ZONE	232	0.910	48.5	.001	72.8	2349	.01
	= 25.63087	+0.38884*	DWELLINGS PER ZONE	232	0.769	27.8	.001	116.8	772	.01
	= -5.00612	+0.40458*	CARS PER ZONE	232	0.970	86.8	.001	42.0	7539	.01
	= 24.17757	+0.33184*	LABOUR FORCE PER ZONE	232	0.831	33.7	.001	99.9	1139	.01
CAPTIVE PRODUCTION PER ZONE mean=78.53 std.dev=92.79	= -1.64537	+0.04373*	POPULATION PER ZONE	232	0.670	21.7	.001	53.4	471	.01
	= -9.43761	+0.15688*	DWELLINGS PER ZONE	232	0.853	36.8	.001	35.6	1351	.01
	= 0.62619	+0.12674*	CARS PER ZONE	232	0.649	20.7	.001	55.1	430	.01
	= -5.12268	+0.12647*	LABOUR FORCE PER ZONE	232	0.823	32.8	.001	39.1	1078	.01
TOTAL ATTRACTION mean=302.40 std.dev=784.34	= 29.85010	+0.44128*	EMPLOYMENT PER ZONE	232	0.912	49.1	.001	233.0	2409	.01
CHOICE ATTRACTION mean=224.73 std.dev=514.52	= 48.40175	+0.28548*	EMPLOYMENT PER ZONE	232	0.887	42.7	.001	173.2	1825	.01
CAPTIVE ATTRACTION mean=77.67 std.dev=276.93	=-18.55257	+0.15579*	EMPLOYMENT PER ZONE	232	0.912	49.1	.001	82.3	2407	.01

result is somewhat surprising since an overall population indicator has no way of differentiating between those trip-makers who have a car available for their trip and those who do not, this being the basis for splitting trip-makers into the choice and captive groups respectively. This inability to differentiate between the status of trip-makers is to some extent reflected in the poorer calibration of captive peak hour work trip production (R^2=0.670, t=21.7) although this relationship is still highly significant (.01).

The use of dwelling units per zone gives rise to similar relationships as population. The correlation is poorer with total peak hour work trips (R^2=0.862, t=38.0) and peak hour choice work trips (R^2=0.769, t=27.8) but gives an improved relationship with peak hour captive work trip production (R^2=0.853, t=36.8) over the corresponding population based equation.

Using the number of cars per zone as the explanatory variable resulted in the most statistically significant equations for total peak hour work trip production (R^2=0.952, t=67.8) and for peak hour choice work trip production (R^2=0.970, t=86.8) but gave the poorest fit of all for peak hour captive work trips (R^2=0.649, t=20.7). The level of car ownership is a logical determinant of the proportion of total work trips that are choice or captive since the availability of a car is the criterion used to discriminate between the two groups of trip-makers. However, it is not a logical determinant of the absolute level of work trip production. On the contrary, the number of work trips made from a zone is a more logical determinant of the number of cars in a zone since each work trip implies a job and each job provides the income necessary to buy a car. In other words, car ownership is a result of work trips, not a cause of them.

The employed labour force per zone represents the number of people in a zone that are employed somewhere. Since almost every person within the labour force will make a work trip at some time during the day, it is to be expected that peak hour work trip production is highly correlated with this variable. The use of labour force as the explanatory variable resulted in the best overall performance in modeling choice work trip production ($R^2=0.831$, $t=33.7$) and captive work trip production ($R^2=0.823$, $t=32.8$). However, the use of such equations in the forecasting of choice and captive peak hour work trip production necessitates the estimatation of zonal levels of labour force which is equivalent to estimating the 24-hour work trip productions. In other words, using labour force as the explanatory variable creates an equivalent problem to the one it solves.

Further development

Despite the extremely high correlations between trip production and the independent variables used, none of the relationships investigated is entirely satisfactory. Car ownership has a plausible basis for splitting trip-makers into the choice or captive groups but no rational basis for determining the absolute levels of work trip production. Population, dwelling units and labour force are logical determinants of work trip production but provide no rational means of identifying choice and captive trip-makers.

TABLE 4.2

SIMPLE CORRELATION BETWEEN EXPLANATORY VARIABLES

	CARS PER ZONE	POPULATION PER ZONE	DWELLINGS PER ZONE	LABOUR FORCE PER ZONE
CARS PER ZONE	1.00	0.98	0.91	0.94
POPULATION PER ZONE	----	1.00	0.94	0.94
DWELLINGS PER ZONE	----	----	1.00	0.98
LABOUR FORCE PER ZONE	----	----	----	1.00

The solution to this problem would appear to be a trip production equation which combines car ownership and either population, dwelling units or labour force. It is not possible to develop such an equation directly using linear regression techniques since all four of these variables are highly colinear. TABLE 4.2 contains the simple correlation matrix for these variables and indicates that the correlation between any two of these variables is greater than 0.9.

An alternative is to develop an equation relating the proportion of total trip productions in each zone that are choice trips to the varying levels of car ownership expressed as cars per person, cars per dwelling unit or cars per labour force. In this way, population can be used as the determinant of total peak hour work trip productions and the best of the above equations can be used to split the total productions into the choice and captive groups. TABLE 4.3(a) contains the results of the ensuing regression analyses.

The data points used to determine these equations were weighted according to the number of peak hour work trips produced in the corresponding traffic zones. For example, a zone producing 105 trips was given a weight of 10 and a zone producing 1763 trips was given a weight of 176. Zones producing less than 10 trips were omitted from the analysis. Without a form of weighting such as this, a zone producing 2 trips of which 1 is choice and 1 is captive would be given equal importance to a zone producing 6000 trips of which 3000 are choice and 3000 are captive. The choice fraction in both cases is 0.5 but the effect of incorrectly estimating the choice fraction would be several hundred times as great, in terms of trips, for the second zone as for the first.

The best of the resulting three weighted regression equations is that which uses cars per dwelling as the

TABLE 4.3

CAR OWNERSHIP AS A DETERMINANT OF CHOICE AND CAPTIVE TRIPMAKERS

(a) LINEAR RELATIONSHIP

DEPENDENT VARIABLE	INTERCEPT	COEFF	INDEPENDENT VARIABLE	DF	R^2	t	sig	error	F	sig
CHOICE PRODUCTION TOTAL PRODUCTION mean=0.756 std.dev=0.092	= 0.47818	+0.80775	*CARS PER PERSON	7453	0.176	39.9	.001	0.083	1593	.01
	= 0.43591	+0.27167	*CARS PER DWELLING	7453	0.807	176.5	.001	0.040	31141	.01
	= 0.37511	+0.39556	*CARS PER LABOUR FORCE	7453	0.750	149.6	.001	0.046	22389	.01

(b) LOGARITHMIC RELATIONSHIP

DEPENDENT VARIABLE	INTERCEPT	COEFF	INDEPENDENT VARIABLE	DF	R^2	t	sig	error	F	sig
CHOICE PRODUCTION TOTAL PRODUCTION mean=0.756 std.dev=0.092	= 1.03426	+0.25836	*Ln[CARS PER PERSON]	7453	0.206	43.9	.001	0.082	1932	.01
	= 0.72199	+0.26918	*Ln[CARS PER DWELLING]	7453	0.776	160.9	.001	0.043	25893	.01
	= 0.77739	+0.35287	*Ln[CARS PER LAB.FORCE]	7453	0.770	157.8	.001	0.044	24915	.01

explanatory variable ($R^2=0.807$, $t=176.5$, $DF=7453$). This produces the following two-stage model for estimating peak hour choice work trip productions:

STAGE 1. $\text{TOTAL PRODUCTION} = -2.02441+0.17685*\text{POPULATION}$

STAGE 2. $\dfrac{\text{CHOICE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.43591+0.27167*\text{CARS/DWELLING}$

FIGURES 4.1 and 4.2 show these two relationships in graphical form.

The overall performance of this two-stage model can be tested by comparing the values of choice production per zone as estimated by these two equations with the corresponding observed values; such a test indicates an extremely good fit ($R^2=0.926$, $t=49.1$, error=64.7, $F=2412$, $DF=193$). Since peak hour captive work trips can be determined by subtracting the peak hour choice work trips from the total work trips, the above two-stage model for estimating choice work trip productions implicitly estimates captive work trip productions also. The overall performance of this implied captive work trip model is not as good as for the choice model but is still highly significant ($R^2=0.770$, $t=24.4$, error=45.2, $F=646$, $DF=193$).

FIGURE 4.2 suggests that a better calibration might be obtained by using a non-linear relationship between the choice fraction of peak hour trip production and car ownership. TABLE 4.3(b) presents the resulting regression equations after logarithmically transforming the car

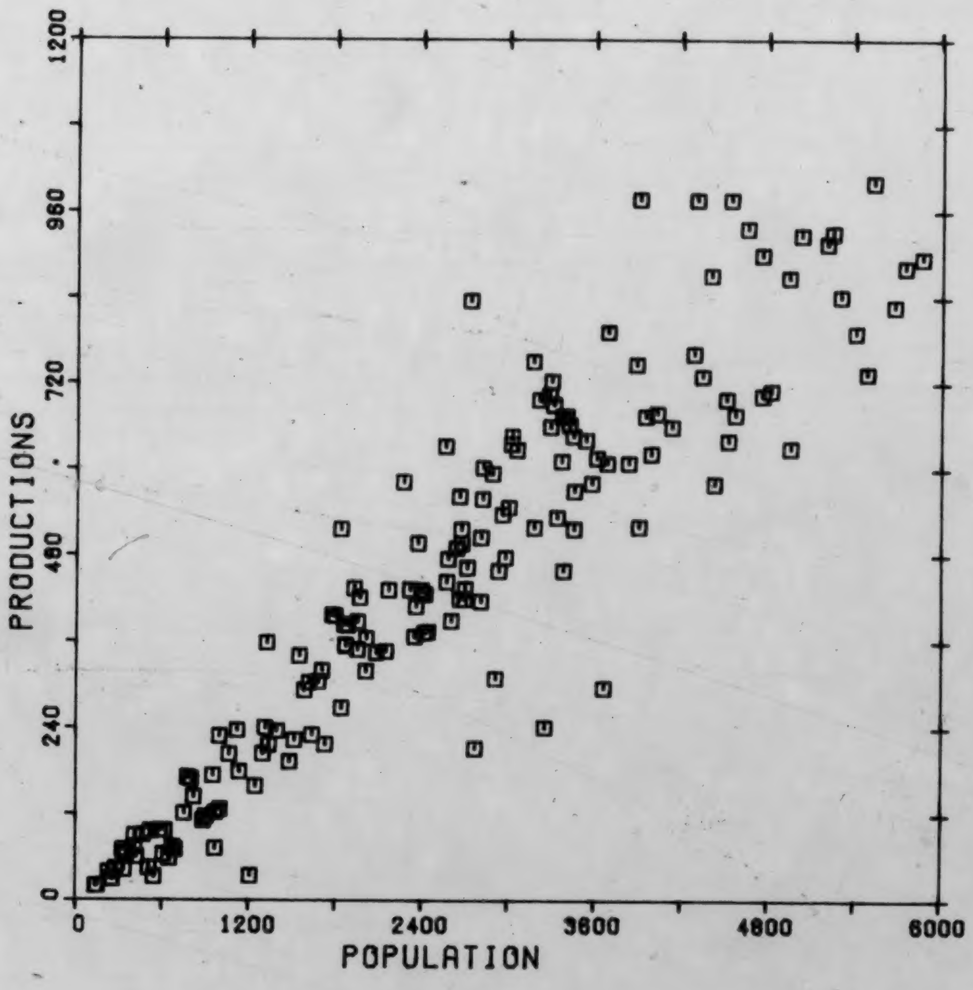


FIGURE 4.1
PEAK HOUR VEHICULAR WORK TRIP PRODUCTIONS
VS POPULATION PER TRAFFIC ZONE

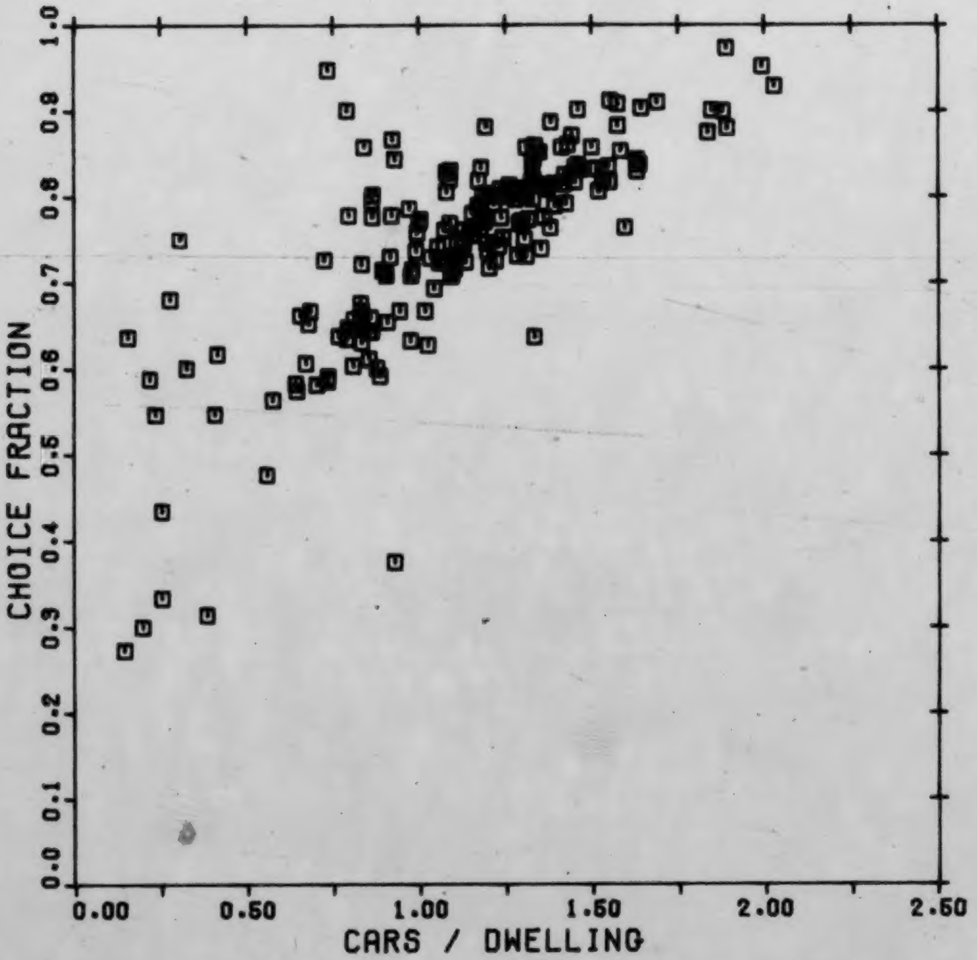


FIGURE 4.2
CHOICE FRACTION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTIONS VS CARS PER DWELLING

ownership variables. The data points used to determine these equations were weighted in the same way as for the linear equations.

The best of the resulting non-linear equations is that which uses the natural logarithm of cars per dwelling as the independent variable. This equation achieves a marginally poorer fit than its linear counterpart but is still highly significant (R^2=0.776, t=161, DF=7543). The resulting two-stage choice production model is:

$$\text{STAGE 1. TOTAL PRODUCTION} = -2.02441+0.17685*\text{POPULATION}$$

$$\text{STAGE 2. } \frac{\text{CHOICE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.72199+0.26918*\text{Ln}(\text{CARS/DWELL})$$

The overall performance of this model proves to be marginally better (R^2=0.928, t=49.8, error=63.9, F=2479, DF=193) than the two-stage linear choice production model but the implied captive model does not perform as well (R^2=0.741, t=23.5, error=48.0, F=553, DF=193). However, from a logical point of view, the choice fraction of total peak hour trip productions would be expected to approach zero as the number of cars per dwelling approaches zero, and to approach unity as the number of cars per dwelling becomes large. FIGURE 4.3 reproduces FIGURE 4.2 with STAGE 2 of each model superimposed; the logarithmic form clearly reflects these logical expectations more closely than the linear form and for this reason the logarithmic production model is likely to give more reliable projections.

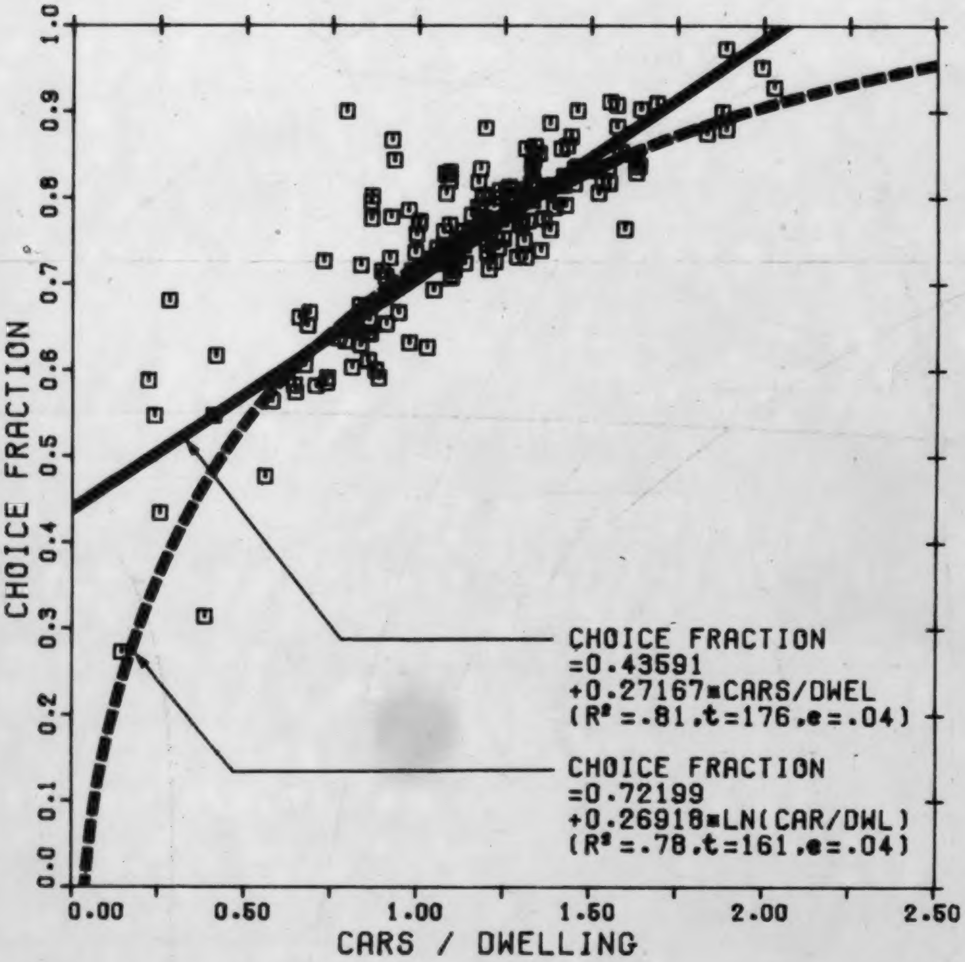


FIGURE 4.3
CHOICE FRACTION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTIONS VS CARS PER DWELLING: ALTERNATIVE MATHEMATICAL REPRESENTATION

The two stages of this model could be combined to give the following single equation:

CHOICE PRODUCTION = -1.46160

+0.12768*POPULATION

-0.54493*Ln[CARS PER DWELLING]

+0.04760*(POPULATION*Ln[CARS PER DWEL])

It should be noted that if population, Ln[cars per dwelling] and the composite variable of Ln[cars per dwelling] multiplied by population had been included directly in a regression equation with choice production per zone, an entirely different set of coefficients would have resulted and the validity of such a model would be questionable due to the effects of colinearity.

Results of calibrating attraction models

The employment per zone represents the total number of people who work in that zone and is therefore equivalent to the number of work trips that will terminate in that zone during a 24-hour period of time. It is logical, therefore, that total peak hour work trip attractions should be highly correlated with employment ($R^2=0.912$, $t=49.1$). The resulting equations for choice and captive trip ends are exceptionally good ($R^2=0.887$, $t=42.7$ and $R^2=0.912$, $t=49.1$ respectively) considering that the single figure of total employment provides no causal basis for splitting trip ends into the two groups. It can only be concluded that in 1971 the split between choice and captive trip attractions was extremely consistent from one zone to another. In future years this may or may not be true but without some causal relationship there is no way of projecting the future split between the two groups apart from assuming that it remains the same as it was in 1971. TABLE 4.1 gives complete details of these equations.

Summary

The equations that have been developed above represent the best peak hour trip generation models that can be obtained using the stated variables. However, it should be realized that a prerequisite of using models which employ such variables is the development of methods to accurately determine the future levels of population, employment, dwelling units, labour force and car ownership. Many studies conveniently ignore this aspect of trip generation modeling, implying by omission that such projections are easy to perform and involve insignificant error levels. In practice, the projection of such variables on a zonal basis is not an easy task; it was indicated above that projecting zonal labour force is equivalent to projecting 24-hour work trip productions and that projecting zonal employment is equivalent to projecting 24-hour work trip attractions. Making such projections is by no means error-free and if these errors were taken into account when forecasting future trip generation levels using equations of the kind described in this chapter, the true accuracy would be considerably less than is indicated by the statistical parameters shown in TABLES 4.1 and 4.3.

CHAPTER V

POSSIBLE MODEL IMPROVEMENTS

Introduction

This chapter presents possible improvements to the trip generation models which were discussed in Chapter II and calibrated to Edmonton data in Chapter IV. The need or opportunity for improvement is first discussed and following this the proposed improvements are presented. The amended models are then calibrated to Edmonton data and the results of calibration presented in a form that can be compared with the results presented in Chapter IV.

The need for improvement

The population and employment based trip generation models that were developed in Chapter IV were shown to fit the base year data extremely well. However, good calibration alone does not necessarily ensure reliable projections and it is in this area that these kinds of models are considered least satisfactory. The ability of all of these models to accurately forecast future trip generation levels is heavily dependent on the accuracy of projections of population, employment, dwelling units and car ownership. It was pointed out in Chapter IV that such projections are not easy to make. The proposed amendments are aimed at overcoming the problems that arise from this dependency on the difficult projection of certain variables.

A framework for improvement

FIGURE 5.1 contains a simplified diagram of the relationships between the various measures of economic activity. It is postulated that economic activity, due to some economic stimulus, results in the simultaneous development of both non-residential and residential land. The development of non-residential land provides employment opportunities and the development of residential land provides accommodation, in the form of dwelling units, for the increase in population required to supply the labour force to fill the jobs created. The filling of these jobs generates work trips between the residential and the non-residential developments and the jobs generate personal income for those employed. Some of this income may be expended by families on the acquisition of automobiles. The productivity generated by those persons employed sustains the current levels of employment and population, and progress may provide additional stimulus for an increase in the level of economic activity.

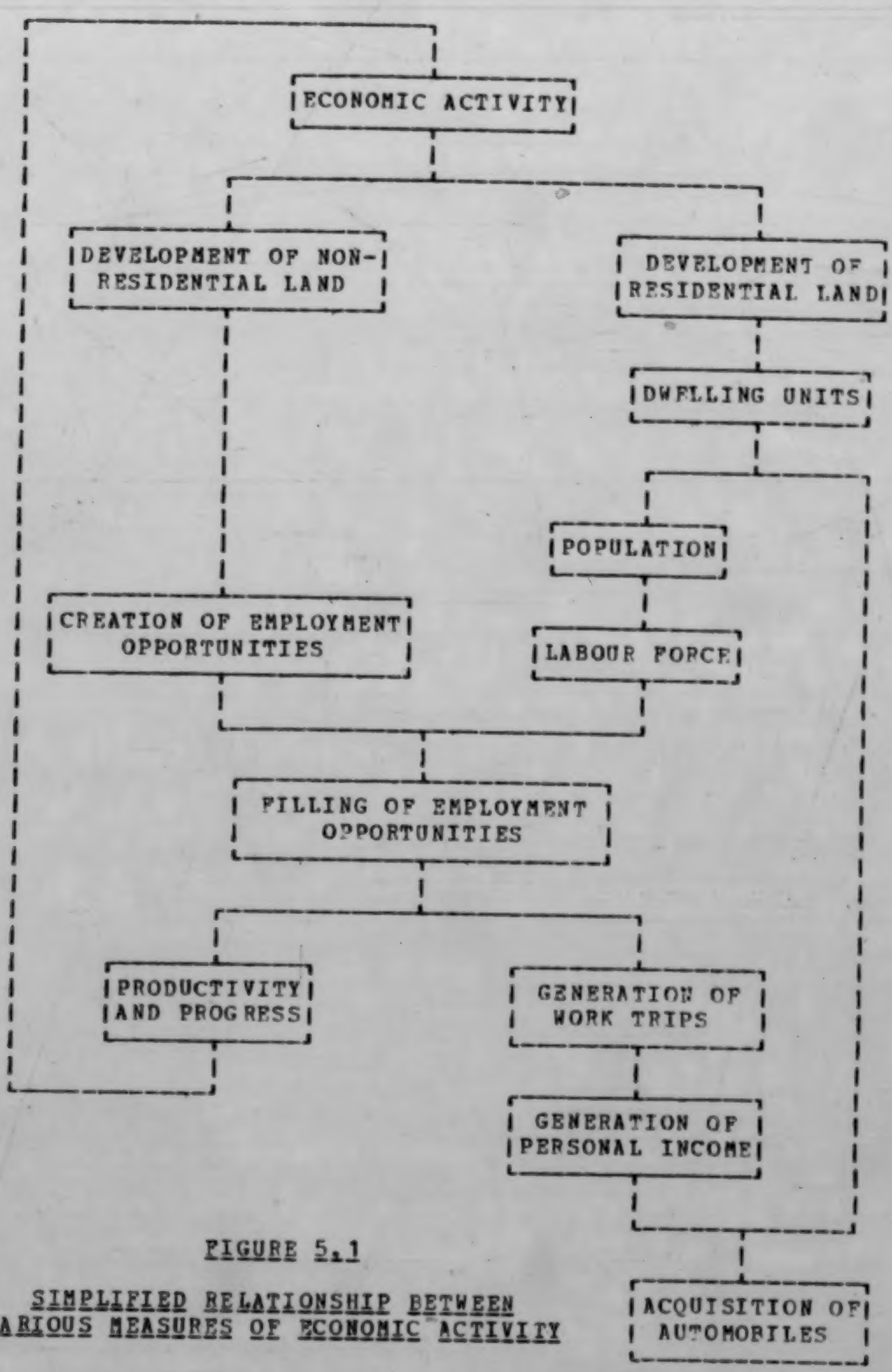

ECONOMIC ACTIVITY
DEVELOPMENT OF NON-RESIDENTIAL LAND
DEVELOPMENT OF RESIDENTIAL LAND
DWELLING UNITS
POPULATION
LABOUR FORCE
CREATION OF EMPLOYMENT OPPORTUNITIES
FILLING OF EMPLOYMENT OPPORTUNITIES
PRODUCTIVITY AND PROGRESS
GENERATION OF WORK TRIPS
GENERATION OF PERSONAL INCOME
ACQUISITION OF AUTOMOBILES

FIGURE 5.1

SIMPLIFIED RELATIONSHIP BETWEEN
VARIOUS MEASURES OF ECONOMIC ACTIVITY

A hypothesis for production models

FIGURE 5.1 shows that dwelling units, population and labour force are all measures of residential activity and suggests that these variables, and consequently work trip production and car ownership, should be highly correlated with residential land development.

This hypothesis is tested in the following manner. The development of residential land in each traffic zone is subdivided into three categories: (i) low density - which includes single family dwellings and duplexes (ii) medium density - which includes row houses, town houses and walk-up apartments and (iii) high density - which includes high-rise apartments. The use of these three categories results from a further hypothesis that people living in each of these types of housing have different lifestyles and exhibit different levels of work trip production and car ownership. An examination of the simple correlation matrix shows a maximum correlation of 0.23 between any two of these land use variables and therefore all three can be considered essentially independent of each other. TABLE 5.1 presents the results of the regression analyses performed to test the hypotheses.

The regression equations presented in TABLE 5.1 show that the three categories of residential land use, expressed as acres of each category within a traffic zone, can be used to explain the various levels of dwelling units, population,

TABLE 5.1

REGRESSION EQUATIONS TO TEST THE HYPOTHESIS THAT DWELLING UNITS, POPULATION, LABOUR FORCE, CAR OWNERSHIP AND WORK TRIP PRODUCTIONS ARE HIGHLY CORRELATED WITH RESIDENTIAL LAND USE DEVELOPMENT

DEPENDENT VARIABLE	INTERCEPT	LOW DENSITY	MED DENSITY	HIGH DENSITY	DF	R^2	error	F ,sig
		COEFF , t	COEFF , t	COEFF , t				
DWELLING UNITS mean=560.7 std.dev=546.4	= 50.53979	5.58042,26.7 sig=.001	18.53168,15.9 sig=.001	38.48370,23.0 sig=.001	230	0.886	186.1	598,.01
POPULATION mean=1833.2 std.dev=1736.6	=103.65933	22.46825,37.4 sig=.001	51.15823,15.3 sig=.001	72.75299,15.1 sig=.001	230	0.907	535.6	747,.01
LABOUR FORCE mean=661.4 std.dev=665.6	= 27.20386	7.33572,29.0 sig=.001	20.23703,14.4 sig=.001	45.42805,22.5 sig=.001	230	0.888	225.1	609,.01
CARS PER ZONE mean=614.6 std.dev=589.9	= 19.90462	8.14942,43.7 sig=.001	12.94037,12.5 sig=.001	27.03169,18.1 sig=.001	230	0.922	166.1	911,.01
TOTAL PEAK HOUR WORK TRIP PRODUCTION mean=322.2 std.dev=321.2	= 6.18011	4.01422,33.2 sig=.001	8.55889,12.7 sig=.001	17.73885,18.3 sig=.001	230	0.890	107.8	619,.01
PEAK HOUR CHOICE WORK TRIP PRODUCTION mean=243.7 std.dev=242.3	= 3.55122	3.30380,36.5 sig=.001	5.16499,10.2 sig=.001	10.73214,14.8 sig=.001	230	0.891	80.7	629,.01
PEAK HOUR CAPTIVE WORK TRIP PRODUCTION mean=78.5 std.dev=92.8	= 2.62784	0.71046,14.8 sig=.001	3.39369,12.7 sig=.001	7.00683,18.3 sig=.001	230	0.793	42.7	293,.01

labour force and car ownership on a traffic zone basis. The intercepts associated with all four relationships are of a reasonably small magnitude and in all cases the partial regression coefficients, which are expressed in terms of dwelling units per acre, population per acre, labour force per acre and cars per acre, are highly significant; the probability of being wrong in assuming that all partial regression coefficients are not zero is appreciably less than 0.001. The coefficient of determination (R^2) is 0.886 for dwelling units, 0.907 for population, 0.888 for labour force and 0.922 for cars per zone, all of which show that residential land use, expressed as acres within each of the three categories, explains a significant amount of the variance in each of these dependent variables. FIGURES 5.2 and 5.3 present two of these four relationships (population and cars per zone) in graphical form.

Calibrating production models

In view of the above results, it is not unexpected that highly significant relationships exist between the three categories of residential land use and peak hour work trip production rates. Equations have been developed for total peak hour work trips, peak hour choice work trips and peak hour captive work trips. TABLE 5.1 shows that the partial regression coefficients for all three equations are highly significant and also shows that the intercept of each equation is extremely small in comparison to the standard

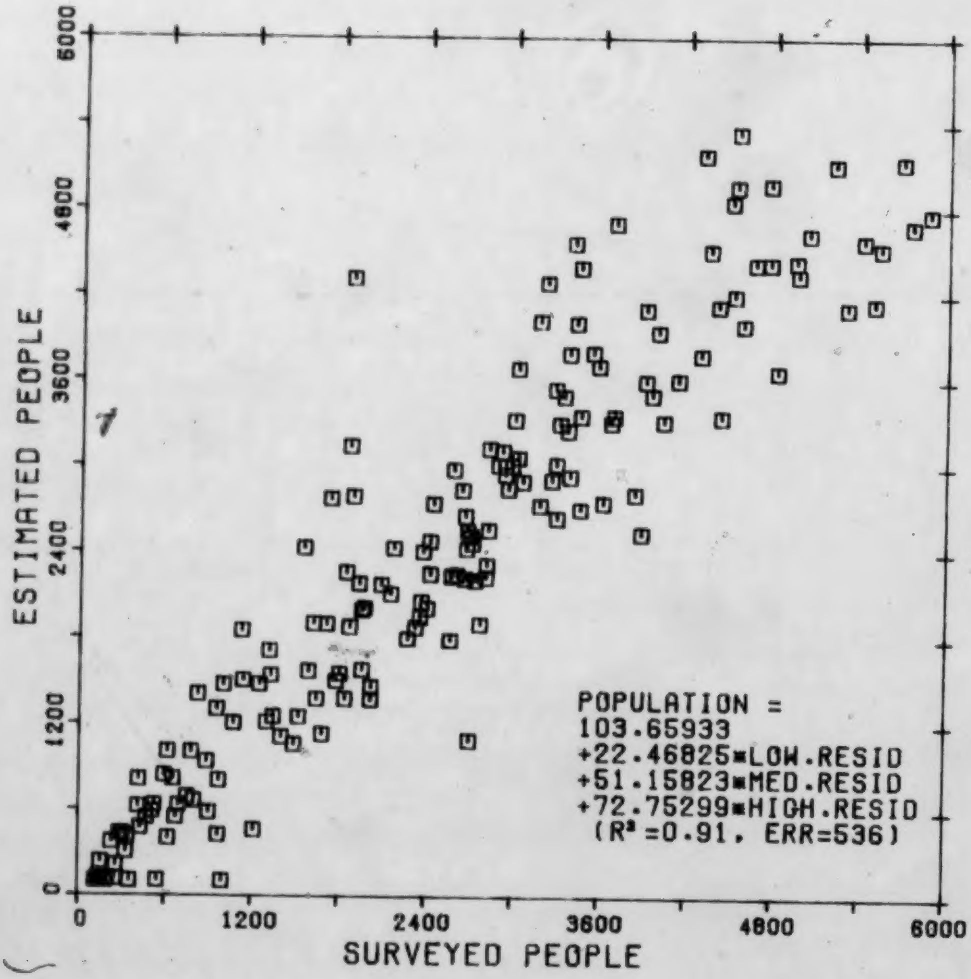


FIGURE 5.2
SURVEYED POPULATION PER ZONE VS
POPULATION ESTIMATED FROM REGRESSION EQUATION
INVOLVING RESIDENTIAL LAND USE CATEGORIES

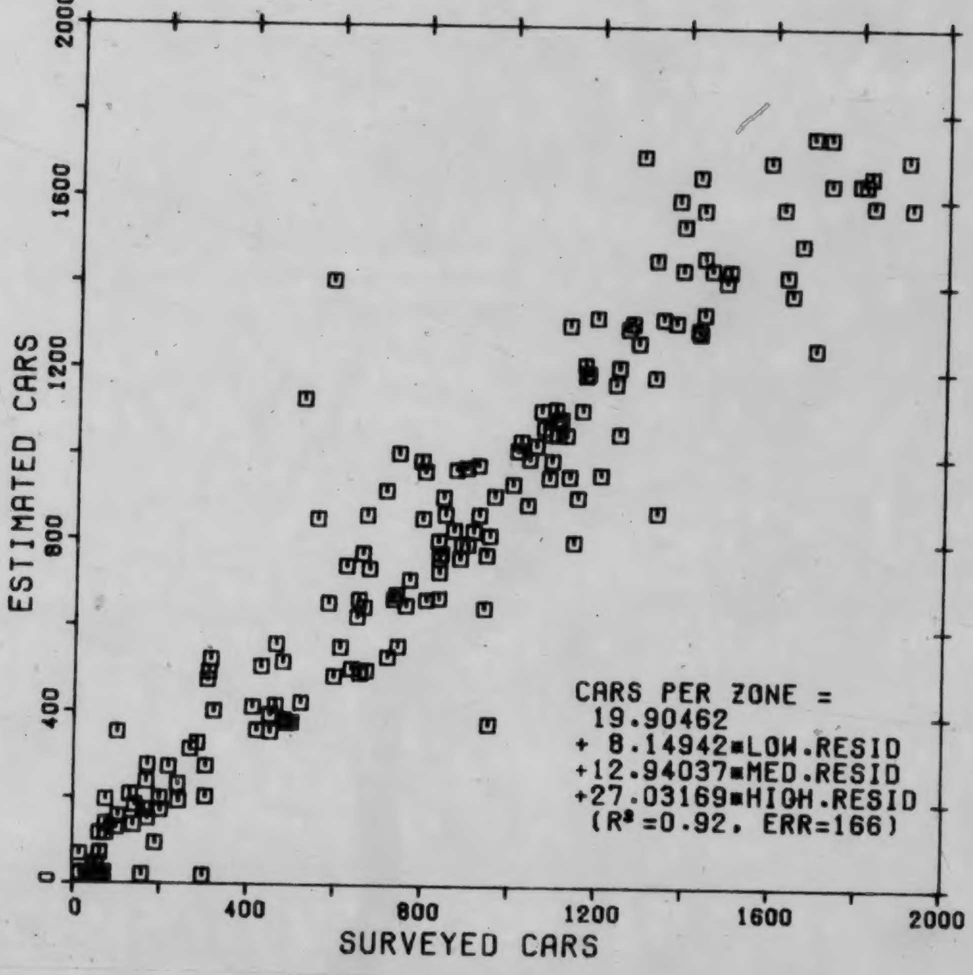


FIGURE 5.3
SURVEYED CARS PER ZONE VS
CARS PER ZONE ESTIMATED FROM REGRESSION EQUATION
INVOLVING RESIDENTIAL LAND USE CATEGORIES

error of estimate; the intercept is a measure of the over-estimation that occurs when the equation is applied to zones with low levels of residential development. The resulting coefficients of determination are 0.890 for total peak hour work trip productions, 0.891 for peak hour choice work trip productions and 0.793 for peak hour captive work trip productions. FIGURE 5.4 contains a plot of surveyed peak hour choice work trip productions against the values estimated by the regression equation.

Results of calibrating production models

TABLE 5.1 and FIGURES 5.2, 5.3 and 5.4 support the hypothesis that dwelling units, population, labour force, car ownership and work trip productions are highly correlated with residential land development.

The second hypothesis that people living within each of the three categories of residential land have different lifestyles and exhibit different levels of work trip production is tested by examining the partial regression coefficients of the equations presented in TABLE 5.1. The coefficients in each equation are different for the three categories of land use which is to be expected since the basis of categorization is housing density; the coefficients in the equation for dwelling units indicate that low density residential land has an average of 5.6 dwelling units per acre, medium density residential land has an average of 18.5

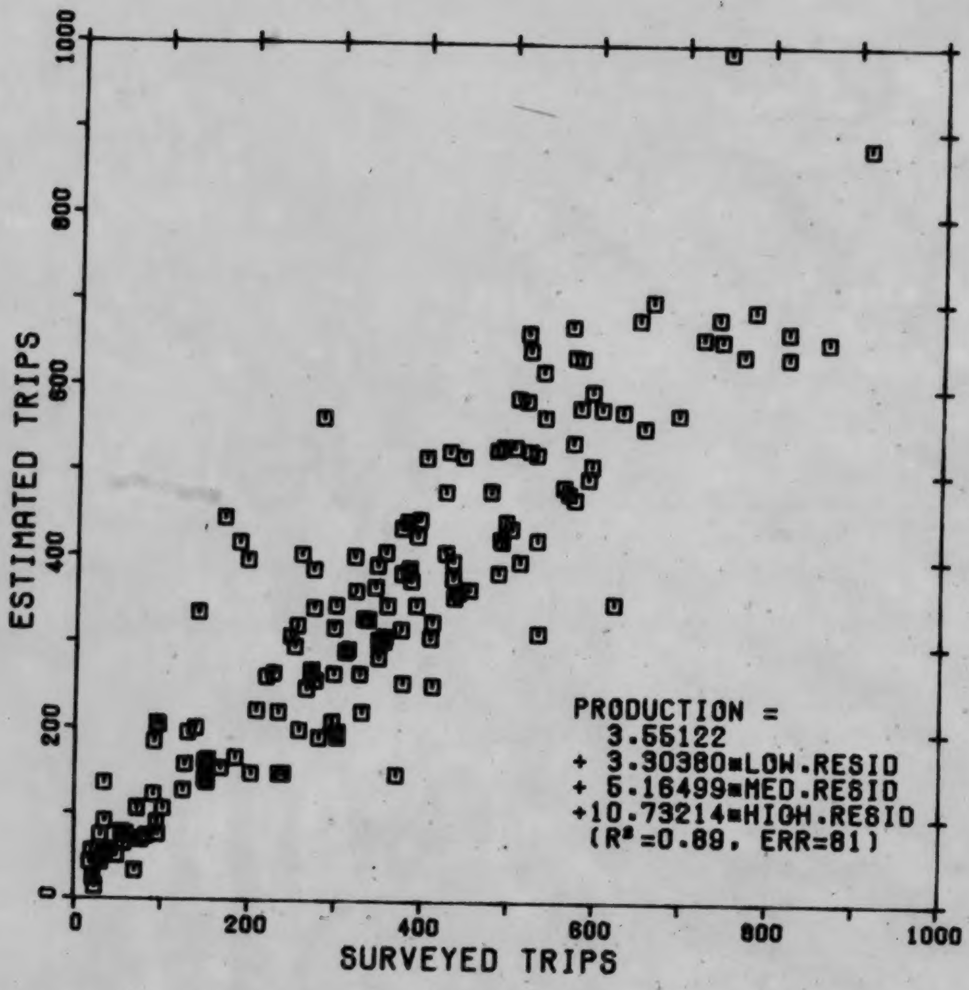


FIGURE 5.4
SURVEYED PEAK HOUR CHOICE PRODUCTION VS PRODUCTION ESTIMATED FROM REGRESSION EQUATION INVOLVING RESIDENTIAL LAND USE CATEGORIES

dwelling units per acre and high density residential land has an average of 38.5 dwelling units per acre. These densities can be used to transform all other equations by dividing the coefficients by the appropriate housing density. The coefficients of the resulting transformed equations now have units such as population per dwelling unit as opposed to population per acre. A similar transformation can be performed by dividing the coefficients by those contained in the population equation; this produces coefficients having units such as labour force per person which represents the labour participation rate. These transformed coefficients allow comparisons to be made between the characteristics of people living in each of the three residential categories on both a household and an individual basis. If people living in the three land use categories have the same lifestyle and the same levels of work trip production and car ownership then, for each of the regression equations, the transformed partial regression coefficients will be equal. TABLE 5.2 summarizes the transformed coefficients and shows that in no equation are all three coefficients the same.

TABLE 5.2 also reveals some interesting differences in the characteristics of people living within the three residential categories. For example, the average household size is 4.02 persons for low density, 2.76 persons for medium density and 1.89 persons for high density and the labour participation rate is 0.33 for low density, 0.40 for

TABLE 5.2

TRANSFORMED PARTIAL REGRESSION COEFFICIENTS INDICATING CHARACTERISTICS IMPLICIT IN RESIDENTIAL* LAND USE CATEGORIZATION

CHARACTERISTIC	RESIDENTIAL LAND USE CATEGORY		
	LOW DENSITY	MED. DENSITY	HIGH DENSITY
POPULATION PER DWELLING UNIT	4.02	2.76	1.89
CARS PER DWELLING UNIT	1.46	0.70	0.70
CARS PER PERSON	0.36	0.25	0.37
LABOUR FORCE PER DWELLING	1.31	1.09	1.18
LABOUR PARTICIPATION RATE	0.33	0.40	0.62
PEAK HOUR WORK TRIPS PER DWELLING UNIT:			
TOTAL	0.72	0.46	0.46
CHOICE	0.59	0.28	0.28
CAPTIVE	0.13	0.18	0.18
PEAK HOUR WORK TRIPS PER PERSON:			
TOTAL	0.18	0.17	0.25
CHOICE	0.15	0.10	0.15
CAPTIVE	0.03	0.07	0.10

medium density and 0.62 for high density. The trip-making characteristics also differ for people within each category, both on a household basis and a per person basis. The peak hour work trip production rate per person is 0.18 for low density, 0.17 for medium density and 0.25 for high density. The population based trip production equation developed in Chapter IV estimated 0.18 trips per person indicating that this equation would overestimate trips from medium density developments and would considerably underestimate trips from high density developments.

TABLE 5.2, therefore, supports the hypothesis that people living within the three categories of residential development have different lifestyles and exhibit different levels of work trip production and car ownership. It also indicates that the city-wide population cannot be considered a homogeneous group with respect to trip-making and that, although residential land use may not provide the best basis for categorization, it can be used to define sub-groups which recognize some of the variation in work trip-making characteristics.

A hypothesis for attraction models

FIGURE 5.1 shows that employment opportunities, and consequently work trip attractions, are measures of non-residential land development. To test whether non-residential land activity can be used to predict the number of employment opportunities in a zone, the development of non-residential land in each zone has been subdivided into five categories: (i) central area office - which includes retail stores and business offices within the downtown area (ii) university-college - which includes all higher education facilities (iii) industrial - which includes all kinds of manufacturing and wholesale facilities (iv) commercial - which includes regional shopping centres and commercial strip development and (v) institutional - which includes schools, hospitals and nursing homes. An examination of the simple correlation matrix shows a maximum correlation of 0.15 between any two of these five land use variables.

Calibrating attraction models

Regression analyses were carried out using (i) total employment per zone (ii) total peak hour work trip attractions per zone (iii) peak hour choice work trip attractions per zone and (iv) peak hour captive work trip attractions per zone as the dependent variables and the quantities of non-residential land within each of the five categories in each traffic zone as the independent variables. TABLE 5.3 presents the resulting equations.

Results of calibrating attraction models

All four regression equations are significant at the

TABLE 5.3

REGRESSION EQUATIONS TO TEST THE HYPOTHESIS THAT TOTAL EMPLOYMENT, PEAK HOUR WORK TRIP ATTRACTION, PEAK HOUR CHOICE WORK TRIP ATTRACTION AND PEAK HOUR CAPTIVE WORK TRIP ATTRACTION ARE HIGHLY CORRELATED WITH NON-RESIDENTIAL LAND USE DEVELOPMENT

	DEPENDENT VARIABLE			
INDEPENDENT VARIABLES AND STATISTICAL INDICATORS	TOTAL EMPLOYMENT PER ZONE mean=617.6 std.dev=1697.6	TOTAL PEAK HOUR WORK TRIP ATTRACTION mean=302.4 std.dev=784.4	PEAK HOUR CHOICE WORK TRIP ATTRACTION mean=224.7 std.dev=514.5	PEAK HOUR CAPTIVE WORK TRIP ATTRACTION mean=77.7 std.dev=277.0
INTERCEPT	170.80600	76.04620	61.10902	18.96579
CENTRAL OFFICE (t, sig)	271.23145 (18.2,.001)	151.18585 (16.9,.001)	95.69777 (15.4,.001)	55.45595 (19.3,.001)
UNIV-COLLEGE (t, sig)	146.78165 (28.1,.001)	52.24638 (16.7,.001)	32.96626 (15.2,.001)	19.27982 (19.2,.001)
INDUSTRIAL (t, sig)	5.60549 (4.0,.001)	3.97938 (4.7,.001)	3.53687 (6.0,.001)	0.44237 (1.6,not sig)
COMMERCIAL (t, sig)	16.61563 (2.3,.05)	5.20495 (1.2,not sig)	4.21661 (1.4,not sig)	0.98600 (0.7,not sig)
INSTITUTIONAL (t, sig)	6.20487 (2.0,.05)	4.14489 (2.2,.05)	2.99716 (2.3,.05)	1.14744 (1.9,.10)
DF	228	228	228	228
R^2	0.830	0.714	0.680	0.763
error	714.5	428.1	296.9	137.4
F, sig	222,.01	114,.01	97,.01	147,.01

.01 level based on the overall F-statistic. However, in all four equations, the intercepts and the standard errors of estimate are high, even though, in comparison to the mean values of the dependent variables on a zonal basis and the standard deviations about these means, the intercepts and standard errors appear less unreasonable. In this aspect, all four equations have room for improvement and the most appropriate way of doing this would be to further disaggregate the non-residential land in each zone by introducing additional land use categories; central area office land, in particular, is in need of such additional disaggregation. Unfortunately, current limitations in data availability preclude this method of modification.

The t-statistics indicate that most coefficients in all four equations are significant at the .001 level although in three of the four equations the coefficient for commercial land is not significant at the 0.1 level. These equations would be considered statistically more significant if commercial land were excluded from the regression analysis. The coefficients of determination are 0.830 for total employment, 0.714 for total peak hour work trip attraction, 0.680 for peak hour choice work trip attraction and 0.763 for peak hour captive work trip attraction.

It is apparent that more appropriate categorization of non-residential land use could possibly improve the calibration of the trip attraction equations. Nevertheless, the equations in TABLE 5.3 provide considerable insight into the characteristics of work trip attractions and show that even the present level of disaggregation helps to explain some of the variation in such characteristics. In particular, these equations show that the employment density varies considerably from a low value of 6 jobs per acre for industrial land to a high of 271 jobs per acre for central area office. In addition, the percentage of these jobs which generate a work trip during the peak hour varies from a low of 31% for commercial land to a high of 71% for industrial land and the percentage of these peak hour trips that are choice trips varies from 63% for central area office to 89% for industrial. TABLE 5.4 summarizes these characteristics.

TABLE 5.4

CHARACTERISTICS IMPLICIT IN NON-RESIDENTIAL LAND USE CATEGORIZATION

	EMPLOYMENT PER ACRE	PEAK HOUR ATTRACTION	PERCENT OF TOTAL	PERCENT CHOICE	PERCENT CAPTIVE
CENTRAL OFFICE	271	151	56%	63%	37%
UNIVERSITY -COLLEGE	147	52	36%	63%	37%
INDUSTRIAL	6	4	71%	89%	11%
COMMERCIAL	17	5	31%	81%	19%
INSTITUTIONAL	6	4	67%	72%	28%

Summary

The models developed in Chapter IV based their forecasting ability on variables such as population, dwelling units, car ownership and employment. This dependency on variables that are difficult to project was considered the major disadvantage of these kinds of models. This Chapter has developed models which relate trip generation directly to variables such as the quantities of residential and non-residential land development, and has presented these as possible improvements over the population and employment based models since the dependency on certain variables has been eliminated. A by-product of these improved models has been a set of equations relating population, dwelling units, car ownership, labour force and employment to the land use variables; these equations allow the population and employment based models to become functional tools. Chapter VI describes a simulated forecasting experiment in which the performance of the land use based models presented in this Chapter is compared with the performance of the population and employment based models developed in Chapter IV.

CHAPTER VI

COMPARISON OF TRIP GENERATION MODELS

Introduction

Chapter II reviewed the kinds of trip generation models that have been employed previously in Edmonton and elsewhere in North America, and Chapter IV verified and calibrated models of these types using data collected in Edmonton in 1971.

Chapter V presented trip generation models based on the quantities of the various categories of residential and non-residential land uses. These models also were verified and calibrated to data collected in Edmonton in 1971.

This Chapter compares the population and employment based models developed in Chapter IV with the land use based models developed in Chapter V and evaluates their performance in an experiment designed to simulate the forecasting process.

The models to be compared

In Chapter IV, a total of 39 production and attraction models were developed to forecast the number of vehicular work trips that would be generated, by each traffic zone, during the morning peak hour. Each model was designed to forecast the choice group of work trips separately from the captive group. These models based their forecasting ability on either one or two of the following independent variables:

(i) population per zone
(ii) dwelling units per zone
(iii) employed labour force per zone
(iv) cars owned per zone
(v) cars per dwelling
(vi) cars per person
(vii) cars per labour force
(viii) Ln(cars per dwelling)
(ix) Ln(cars per person)
(x) Ln(cars per labour force)
(xi) employment per zone

Based on the 'goodness of fit' of calibration and the rationality of the formulation, the following production and attraction models are considered to be the best of the population and employment based trip generation models developed in Chapter IV:

(i) total production model

TOTAL PRODUCTION =-2.02441+0.17685*POPULATION

(ii) choice production model

$$\frac{\text{CHOICE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.72199+0.26918*\text{Ln}[\text{CARS PER DWELLING}]$$

(iii) captive production model

$$\frac{\text{CAPTIVE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.27801-0.26918*\text{Ln}[\text{CARS PER DWELLING}]$$

(iv) total attraction model

TOTAL ATTRACTION = 39.39746+0.43960*EMPLOYMENT

(v) choice attraction model

CHOICE ATTRACTION = 48.40175+0.28548*EMPLOYMENT

(vi) captive attraction model

CAPTIVE ATTRACTION = -18.55257+0.15579*EMPLOYMENT

The models developed in Chapter V related trip generation to the quantities of land within the following land use categories:

(i) low density residential land
(ii) medium density residential land
(iii) high density residential land
(iv) central area office development
(v) university-college land
(vi) industrial land
(vii) commercial land
(viii) institutional land

The land use based production models are presented in TABLE 5.1 and the attraction models in TABLE 5.3.

A framework for comparison

Since the purpose of trip generation models is to provide a rational means of forecasting trip productions and attractions to some point in the future, the most realistic method of evaluating the performance of alternative models is to use each model in turn to forecast the levels of trip generation for some future year. However, the actual future generation levels will not be known until the forecast year is reached, so that this method provides no immediate way of determining which models are the most accurate.

The actual generation levels are known for 1971. An alternative, then, is to simulate the forecasting process by using each model to forecast productions and attractions for the year 1971 using only that information that would have been available at some time, for example 10 or 15 years, prior to 1971. The performance of each model can then be immediately determined by comparing the 10 to 15 year projections of productions and attractions against the actual levels measured in 1971.

Method of comparison

The following method has been selected for comparing the performance of trip generation models:

(i) FIGURE 6.1 indicates the traffic zones that were fully developed sometime prior to 1961 and those zones that were developed between 1961 and 1971.

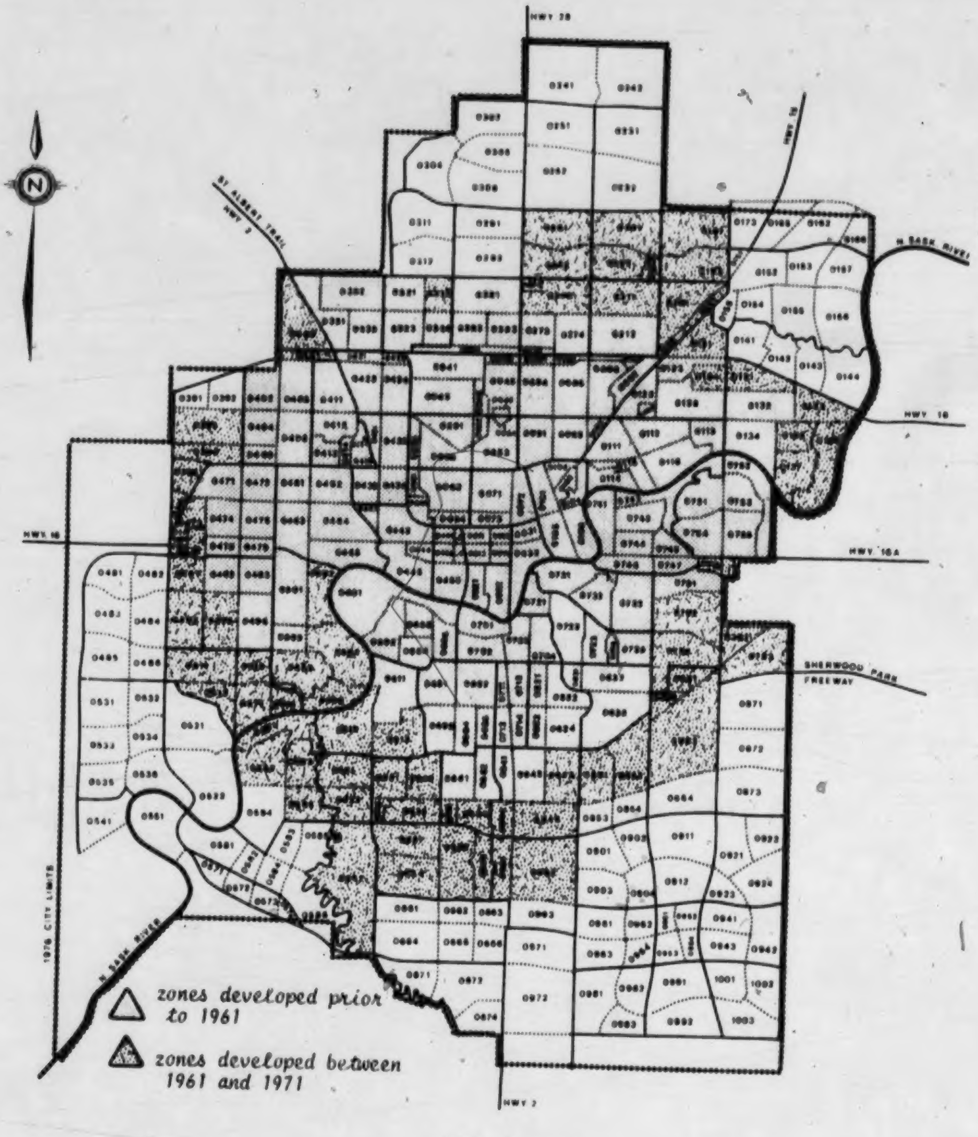

N
HWY 28
HWY 28
ST ALBERT TRAIL
HWY 2
N SASK RIVER
HWY 16
HWY 16
HWY 16A
SHERWOOD PARK FREEWAY
1976 CITY LIMITS
N SASK RIVER
HWY 2
△ zones developed prior to 1961
▲ zones developed between 1961 and 1971

FIGURE 6.1: ZONES DEVELOPED PRIOR TO 1961

(ii) All models will be recalibrated using only the data corresponding to zones developed prior to 1961. It will be assumed that the data collected for these zones in 1971 are representative of what existed in 1961.

(iii) The recalibrated models will be used to forecast trip production and attraction levels for zones that were developed between 1961 and 1971.

(iv) These forecasts will be compared with the production and attraction levels measured in 1971.

The population and employment based models require projections of population, employment, dwelling units and cars per zone, since their forecasts of trip generation are based on these variables. All four variables will be projected from 1961 to 1971 using land use based equations of the type shown in TABLES 5.1 and 5.3. These equations will be recalibrated to data corresponding to those zones developed prior to 1961.

Results of recalibrating models

TABLES 6.1, 6.2 and 6.3 contain the results of recalibrating all models and equations to data corresponding to the 162 traffic zones developed prior to 1961. Although 162 zones were developed prior to 1961, only 88 were used in the recalibration of production models and 89 in the recalibration of attraction models. It was noted in

TABLE 6.1

WORK TRIP GENERATION REGRESSION EQUATIONS BASED ON TRAFFIC ZONES DEVELOPED PRIOR TO 1961

DEPENDENT VARIABLE	INTERCEPT	COEFF	INDEPENDENT VARIABLE	DF	R^2	t	, sig	error	F	,sig
TOTAL PRODUCTION mean=557.50 std.dev=246.64	= -7.84912	+0.17900	*POPULATION PER ZONE	86	0.705	14.3	.001	134.7	206	.01
CHOICE PRODUCTION TOTAL PRODUCTION mean=0.731 std.dev=0.081	= 0.71227	+0.27288	*Ln[CARS PER DWELLING]	4866	0.785	133.1	.001	0.038	17724	.01
TOTAL ATTRACTION mean=561.83 std.dev=1074.23	= 80.77759	+0.41319	*EMPLOYMENT PER ZONE	87	0.928	33.4	.001	290.3	1118	.01
CHOICE ATTRACTION mean=409.72 std.dev=688.97	=105.01855	+0.26172	*EMPLOYMENT PER ZONE	87	0.905	28.8	.001	213.7	828	.01
CAPTIVE ATTRACTION mean=152.11 std.dev=394.39	=-24.23750	+0.15147	*EMPLOYMENT PER ZONE	87	0.925	32.8	.001	108.6	1073	.01

TABLE 6.2

DWELLING UNITS, POPULATION, CARS PER ZONE AND WORK TRIP PRODUCTION EQUATIONS CALIBRATED TO RESIDENTIAL LAND USE DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961

DEPENDENT VARIABLE	INTERCEPT	LOW DENSITY	MED DENSITY	HIGH DENSITY	DF	R^2	error	F ,sig
		COEFF , t	COEFF , t	COEFF , t				
DWELLING UNITS mean=1001.5 std.dev=439.5	=222.67847	4.65684,11.1 sig=.001	20.00980,14.2 sig=.001	29.83395,14.5 sig=.001	84	0.842	179.7	149,.01
POPULATION mean=3158.4 std.dev=1157.2	=616.22900	18.60945,15.7 sig=.001	52.86188,13.3 sig=.001	53.62987, 9.2 sig=.001	84	0.819	507.5	126,.01
CARS PER ZONE mean=1051.6 std.dev=393.3	=144.40302	7.18472,18.1 sig=.001	12.82802, 9.6 sig=.001	22.39944,11.5 sig=.001	84	0.824	169.7	132,.01
TOTAL PEAK HOUR WORK TRIP PRODUCTION mean=557.5 std.dev=246.6	= 48.60126	3.70378,12.4 sig=.001	8.77042, 8.8 sig=.001	15.79355,10.8 sig=.001	84	0.748	127.6	83,.01
PEAK HOUR CHOICE WORK TRIP PRODUCTION mean=407.6 std.dev=169.6	= 36.09985	2.97354,14.4 sig=.001	4.78611, 6.9 sig=.001	9.65923, 9.5 sig=.001	84	0.744	88.4	81,.01
PEAK HOUR CAPTIVE WORK TRIP PRODUCTION mean=149.9 std.dev=97.3	= 12.49855	0.73026, 5.7 sig=.001	3.98435, 9.4 sig=.001	6.13451, 9.8 sig=.001	84	0.706	54.3	67,.01

TABLE 6.3

EMPLOYMENT AND WORK TRIP ATTRACTION EQUATIONS CALIBRATED TO NON-RESIDENTIAL LAND USE DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961

	DEPENDENT VARIABLE			
INDEPENDENT VARIABLES AND STATISTICAL INDICATORS	TOTAL EMPLOYMENT PER ZONE mean=1164.2 std.dev=2504.2	TOTAL PEAK HOUR WORK TRIP ATTRACTION mean=561.8 std.dev=1074.2	PEAK HOUR CHOICE WORK TRIP ATTRACTION mean=409.7 std.dev=689.0	PEAK HOUR CAPTIVE WORK TRIP ATTRACTION mean=152.1 std.dev=394.4
INTERCEPT	298.12744	135.49028	103.59509	31.89322
CENTRAL OFFICE (t, sig)	257.93213 (20.8,.001)	143.04539 (18.7,.001)	90.08997 (16.6,.001)	52.95253 (21.4,.001)
UNIV-COLLEGE (t, sig)	152.84753 (35.3,.001)	54.40953 (20.4,.001)	34.33693 (18.2,.001)	20.07269 (23.2,.001)
INDUSTRIAL (t, sig)	7.86008 (4.5,.001)	5.58901 (5.2,.001)	4.92863 (6.5,.001)	0.66054 (1.9,.10)
COMMERCIAL (t, sig)	27.22668 (2.3,.05)	10.25057 (1.4,not sig)	8.80017 (1.7,.10)	1.45272 (0.6,not sig)
INSTITUTIONAL (t, sig)	4.44703 (1.0,not sig)	2.51751 (0.9,not sig)	2.00480 (1.0,not sig)	0.51189 (0.6,not sig)
DF	83	83	83	83
R^2	0.952	0.901	0.879	0.923
error	578.0	356.1	252.5	145.5
F, sig	329,.01	151,.01	121,.01	198,.01

Chapter III that the City of Edmonton Planning Department advized of possible inaccuracies in the land use data; closer scrutiny of these data on an individual zone basis identified some of the inaccuracies. For example, zone 0406 has a population of 356 people but is recorded as having no residential development and zone 0701 has a total employment of 150 yet is recorded as having no non-residential development. All zones such as these have been excluded from the recalibration of models and equations. Recalibration has changed the coefficients of all equations; the majority of changes are within the expected range of ±5% and the exceptions to this involve coefficients that are considered statistically insignificant in one or other equation, or small coefficients where a small absolute change has resulted in a large percentage change. Overall, the statistical significance of the recalibrated equations is equivalent to that of the original equations.

The resulting production models

The resulting six peak hour vehicular work trip production models are as follows.

MODEL 1

TOTAL PRODUCTION = -7.84912+0.17900*POPULATION

MODEL 2

TOTAL PRODUCTION = 48.60126
+ 3.70378*LOW DENSITY RESIDENTIAL LAND
+ 8.77042*MEDIUM DENSITY RESIDENTIAL LAND
+15.79355*HIGH DENSITY RESIDENTIAL LAND

MODEL 3

$$\frac{\text{CHOICE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.71227+0.27288*\text{Ln}[\text{CARS PER DWELLING}]$$

MODEL 4

$$\begin{aligned}\text{CHOICE PRODUCTION} = {} & 36.09985\\ & + 2.97354*\text{LOW DENSITY RESIDENTIAL LAND}\\ & + 4.78611*\text{MEDIUM DENSITY RESIDENTIAL LAND}\\ & + 9.65923*\text{HIGH DENSITY RESIDENTIAL LAND}\end{aligned}$$

MODEL 5

$$\frac{\text{CAPTIVE PRODUCTION}}{\text{TOTAL PRODUCTION}} = 0.28773-0.27288*\text{Ln}[\text{CARS PER DWELLING}]$$

MODEL 6

$$\begin{aligned}\text{CAPTIVE PRODUCTION} = {} & 12.49855\\ & + 0.73026*\text{LOW DENSITY RESIDENTIAL LAND}\\ & + 3.98435*\text{MEDIUM DENSITY RESIDENTIAL LAND}\\ & + 6.13451*\text{HIGH DENSITY RESIDENTIAL LAND}\end{aligned}$$

MODEL 1 will be compared with MODEL 2; MODEL 3 will be compared with MODEL 4; and MODEL 5 will be compared with MODEL 6.

APPENDIX B contains the calibration statistics for these six production models. TABLE B.1 compares the calibrated values, for each of the 88 zones used in the recalibration, for MODEL 1 and MODEL 2. This TABLE shows that both models exhibit considerable calibration error on an individual zone basis, and that the combined calibration error for the 88 zones used in recalibration amounts to 8269 trips for MODEL 1 and 7760 trips for MODEL 2. These two numbers result from summing the absolute values of all deviations from the actual zonal production levels, and represent the the number of trips that have been incorrectly reproduced by the models. As a percentage of the total trips produced in all 88 zones, these calibration errors can be expressed as 16% for MODEL 1 and 15% for MODEL 2.

TABLE B.2 compares the calibrated values for MODEL 3 and MODEL 4. The total calibration errors for these two models amount to 6142 trips for MODEL 3 (17%) and 5662 trips for MODEL 4 (15%).

The calibration errors for MODEL 5 and MODEL 6 are presented in TABLE B.3. The total errors for these models are 3321 trips for MODEL 5 (25%) compared with 3218 trips for MODEL 6 (24%).

In all cases, therefore, the models which relate trip production directly to the quantities of residential land development (MODELS 2, 4 and 6) exhibit slightly better calibration than those models which relate trip production to population and car ownership (MODELS 1, 3 and 5).

Comparison of trip production forecasts

The land use data for the 72 zones developed between 1961 and 1971 was inspected in the same way as the land use data for the 162 zones developed prior to 1961. All zones exhibiting contradictory information, together with zones that are primarily non-residential, were removed from this data set for the purpose of forecasting trip productions.

For example, zone 0633 has a total trip production of 228 but is recorded as having no residential development and zone 0845 is exclusively non-residential. The six trip production models, calibrated to zones developed prior to 1961, were used to forecast production levels for the 37 zones that remained after this operation.

TABLE 6.4 presents the total peak hour vehicular work trip production levels forecast by MODELS 1 and 2 for these 37 zones. MODEL 1 overestimates the total of 19536 trips produced in these 37 zones by approximately 400 trips; MODEL 2 underestimates the total by approximately 250. The individual zonal deviations from the production levels measured in 1971 vary widely from zone to zone. The sum of the absolute values of these deviations totals 3165 trips for MODEL 1 and 2832 trips for MODEL 2. Expressed as a percentage of the total trips produced in all 37 zones, these errors amount to 16% for MODEL 1 and 14% for MODEL 2.

TABLE 6.5 presents the peak hour choice vehicular work trips forecast by MODELS 3 and 4. Both models underestimate the overall 16419 choice trip productions by approximately 1500 trips. The sum of the absolute values of the individual zonal deviations totals 2866 trips for MODEL 3 and 2808 trips for MODEL 4. Both of these error levels represent approximately 17% of the total choice trip productions.

TABLE 6.6 compares the peak hour captive vehicular work trip levels as forecast by MODELS 5 and 6. Both models

TABLE 6.4

COMPARISON OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTIONS AS ESTIMATED BY MODEL 1 AND MODEL 2

ZONE NUMBER	ESTIMATED 1971 TOTAL PEAK HOUR PRODUCTIONS		ACTUAL 1971 TRIP PRODUCTIONS	ESTIMATION ERROR			
				MODEL 1		MODEL 2	
	MODEL 1	MODEL 2		TRIPS	%	TRIPS	%
124	173	128	117	56	47	11	9
131	207	164	122	85	69	42	34
135	247	207	193	54	27	14	7
137	425	401	443	-18	-4	-42	-9
191	508	500	537	-29	-5	-37	-6
192	793	770	703	90	12	67	9
201	763	753	630	133	21	123	19
211	800	819	896	-96	-10	-77	-8
221	912	887	916	-4	0	-29	-3
222	615	590	609	6	0	-19	-3
262	558	527	475	83	17	52	10
272	801	773	869	-68	-7	-96	-11
322	427	400	416	11	2	-16	-3
473	254	215	236	18	7	-21	-8
491	404	364	349	55	15	15	4
494	473	451	747	-274	-36	-296	-39
495	579	578	678	-99	-14	-100	-14
504	422	403	268	154	57	135	50
505	680	691	662	18	2	29	4
511	797	807	883	-86	-9	-76	-8
512	322	292	388	-66	-17	-96	-24
513	525	495	383	142	37	112	29
514	447	431	431	16	3	0	0
593	356	316	240	116	48	76	31
595	296	264	144	152	105	120	83
612	448	432	340	108	31	92	27
622	591	556	384	207	53	172	44
632	531	511	627	-96	-15	-116	-18
634	465	452	497	-32	-6	-45	-9
641	738	755	646	92	14	109	16
651	973	928	977	-4	0	-49	-5
652	384	347	320	64	20	27	8
653	174	129	45	129	286	84	186
654	776	795	928	-152	-16	-133	-14
684	281	289	319	-38	-11	-30	-9
782	1031	1063	1117	-86	-7	-54	-4
783	773	781	1001	-228	-22	-220	-21
TOTALS	19949	19264	19536	3165	16	2832	14

TABLE 6.5

COMPARISON OF PEAK HOUR CHOICE VEHICULAR WORK TRIP PRODUCTIONS AS ESTIMATED BY MODEL 3 AND MODEL 4

ZONE NUMBER	ESTIMATED 1971 PEAK HOUR CHOICE PRODUCTIONS		ACTUAL 1971 TRIP PRODUCTIONS	ESTIMATION ERROR			
				MODEL 3		MODEL 4	
	MODEL 3	MODEL 4		TRIPS	%	TRIPS	%
124	120	100	83	37	44	17	20
131	147	129	103	44	42	26	25
135	178	160	150	28	18	10	6
137	320	310	356	-36	-10	-46	-12
191	398	399	425	-27	-6	-26	-6
192	574	554	604	-30	-4	-50	-8
201	571	564	507	64	12	57	11
211	632	647	739	-107	-14	-92	-12
221	654	628	743	-89	-11	-115	-15
222	450	434	495	-45	-9	-61	-12
262	403	384	384	19	4	0	0
272	574	549	693	-119	-17	-144	-20
322	319	307	349	-30	-8	-42	-12
473	184	166	203	-19	-9	-37	-18
491	286	265	276	10	3	-11	-3
494	356	347	621	-265	-42	-274	-44
495	456	462	567	-111	-19	-105	-18
504	326	321	255	71	27	66	25
505	540	552	579	-39	-6	-27	-4
511	619	626	721	-102	-14	-95	-13
512	242	231	331	-89	-26	-100	-30
513	382	364	345	37	10	19	5
514	346	343	392	-46	-11	-49	-12
593	253	233	209	44	21	24	11
595	221	209	130	91	70	79	60
612	346	342	299	47	15	43	14
622	420	396	320	100	31	76	23
632	399	390	511	-112	-21	-121	-23
634	362	360	453	-91	-20	-93	-20
641	588	604	581	7	1	23	3
651	671	629	866	-195	-22	-237	-27
652	276	257	267	9	3	-10	-3
653	121	100	30	91	303	70	233
654	617	632	819	-202	-24	-187	-22
684	192	204	281	-89	-31	-77	-27
782	808	827	912	-104	-11	-85	-9
783	600	606	820	-220	-26	-214	-26
TOTALS	14951	14631	16419	2866	17	2808	17

TABLE 6.6

COMPARISON OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP PRODUCTIONS AS ESTIMATED BY MODEL 5 AND MODEL 6

ZONE NUMBER	ESTIMATED 1971 PEAK HOUR CAPTIVE PRODUCTIONS		ACTUAL 1971 TRIP PRODUCTIONS	ESTIMATION ERROR			
				MODEL 5		MODEL 6	
	MODEL 5	MODEL 6		TRIPS	%	TRIPS	%
124	54	28	34	20	58	-6	-17
131	59	35	19	40	210	16	84
135	69	47	43	26	60	4	9
137	105	90	87	18	20	3	3
191	111	102	112	-1	0	-10	-8
192	219	215	99	120	121	116	117
201	191	189	123	68	55	66	53
211	168	172	157	11	7	15	9
221	259	258	173	86	49	85	49
222	165	156	114	51	44	42	36
262	155	143	91	64	70	52	57
272	228	223	176	52	29	47	26
322	108	93	67	41	61	26	38
473	71	48	33	38	115	15	45
491	117	99	73	44	60	26	35
494	117	104	126	-9	-7	-22	-17
495	123	117	111	12	10	6	5
504	96	82	13	83	638	69	530
505	140	139	83	57	68	56	67
511	178	181	162	16	9	19	11
512	79	61	57	22	38	4	7
513	144	131	38	106	278	93	244
514	100	88	39	61	156	49	125
593	102	83	31	71	229	52	167
595	75	55	14	61	435	41	292
612	102	90	41	61	148	49	119
622	171	159	64	107	167	95	148
632	132	121	116	16	13	5	4
634	103	92	44	59	134	48	109
641	150	152	65	85	130	87	133
651	302	300	111	191	172	189	170
652	109	91	53	56	105	38	71
653	54	28	15	39	260	13	86
654	159	163	109	50	45	54	49
684	89	84	38	51	134	46	121
782	223	236	205	18	8	31	15
783	173	174	181	-8	-4	-7	-3
TOTALS	5000	4629	3117	1919	61	1602	51

grossly overestimate the captive trips produced, both on an individual zonal basis and for the 37 zones in total. Misallocation of captive trip productions by MODEL 5 amounts to 61% of the total captive trips; misallocation by MODEL 6 amounts to 51%.

In summary, none of the six production models accurately forecasts the production levels on a traffic zone basis. However, the level of acceptibility is slightly higher for the three models which base their forecasts directly on the quantities of residential land development (MODELS 2, 4 and 6) than it is for MODELS 1, 3 and 5 which relate trip production to zonal population and car ownership.

The resulting attraction models

The six resulting peak hour vehicular work trip attraction models are as follows.

MODEL 7

TOTAL ATTRACTION = 80.77759+0.41319*EMPLOYMENT

MODEL 8

```
TOTAL ATTRACTION = 135.49028
                  +143.04539*CENTRAL OFFICE
                  + 54.40953*UNIVERSITY-COLLEGE
                  +  5.58901*INDUSTRIAL
                  + 10.25057*COMMERCIAL
                  +  2.51751*INSTITUTIONAL
```

MODEL 9

CHOICE ATTRACTION = 105.01855+0.26172*EMPLOYMENT

MODEL 10

CHOICE ATTRACTION = 103.59509
+ 90.08992*CENTRAL OFFICE
+ 34.33693*UNIVERSITY-COLLEGE
+ 4.92863*INDUSTRIAL
+ 8.80017*COMMERCIAL
+ 2.00480*INSTITUTIONAL

MODEL 11

CAPTIVE ATTRACTION = -24.23750+0.15147*EMPLOYMENT

MODEL 12

CAPTIVE ATTRACTION = 31.89322
+52.95253*CENTRAL OFFICE
+20.07269*UNIVERSITY-COLLEGE
+ 0.66054*INDUSTRIAL
+ 1.45272*COMMERCIAL
+ 0.51189*INSTITUTIONAL

MODEL 7 is compared with MODEL 8; MODEL 9 is compared with MODEL 10; and MODEL 11 is compared with MODEL 12.

APPENDIX C contains the calibration statistics for these six attraction models. TABLE C.1 presents the calibrated values, for each of the 89 zones used in the recalibration, for MODEL 7 and MODEL 8. These values show that both models exhibit considerable error on an individual zone basis, the deviations ranging from -56% to +291% for MODEL 7 and from -61% to +201% for MODEL 8. The sum of the absolute values of these zonal deviations amounts to 19119 trips for MODEL 7 and 15349 trips for MODEL 8 which, expressed as a percentage of the total 50003 attractions, represent 38% and 30% error respectively.

TABLE C.2 presents the calibrated zonal choice attraction levels for MODELS 9 and 10. The zonal deviations are of a similar magnitude to those for MODELS 7 and 8, and the overall calibration errors, expressed as a percentage of the total 36465 choice attractions, amount to 40% for MODEL 9 and 31% for MODEL 10.

The calibration errors for MODELS 11 and 12 are presented in TABLE C.3. The overall calibration errors for these two models, expressed as a percentage of the total 13538 captive attractions, amount to 39% for MODEL 11 and 32% for MODEL 12.

The calibration results of these six trip attraction models are disappointing. TABLES 6.1 and 6.3 show that the coefficients of determination (R^2) are all high indicating that the relationships between trip attraction and the independent variables are strong. However, in all cases the intercepts are extremely high as are the standard errors of estimates, both of which are considered to be primarily caused by poor land use data. These models, in their present form, are considered inadequate for the projection of trip attraction levels on a zonal basis. The following section presents the results of attempting to use them for this purpose.

Comparison of trip attraction forecasts

Employment in Edmonton is concentrated into a few traffic zones as shown in FIGURE 3.6 on page 41, and most of these employment zones were fully or partially developed prior to 1961. Those zones developed between 1961 and 1971 included very few new employment areas; most non-residential development during this ten-year period took place in zones already partially developed prior to 1961.

Consequently, the chosen method of comparing trip generation models is not as applicable to attraction models as it is to production models. Only 24 zones developed between 1961 and 1971 exhibit any appreciable non-residential development and many of these are primarily residential zones in which neighbourhood shopping centres constitute the non-residential development. As such, the employment levels in these zones are low; the average employment level is less than half the average of those zones developed prior to 1961 and for many zones it is less than the intercept term in the trip attraction models. It is not unexpected, therefore, that all six attraction models overestimate the trip attraction levels for the zones developed between 1961 and 1971.

TABLE 6.7 presents the total peak hour vehicular work trip attraction forecasts by MODELS 7 and 8. Both models grossly overestimate the total of 6010 trips attracted by the 24 zones; MODEL 7 overestimates by approximately 3000 trips and MODEL 8 by almost 4000 trips.

This overestimation is carried through to MODELS 9 and 10 and to MODELS 11 and 12. TABLES 6.8 and 6.9 present the forecasts for these models and show that they overestimate

TABLE 6.7

COMPARISON OF TOTAL PEAK HOUR VEHICULAR WORK TRIP ATTRACTIONS AS ESTIMATED BY MODEL 7 AND MODEL 8

ZONE NUMBER	ESTIMATED 1971 TOTAL PEAK HOUR ATTRACTIONS		ACTUAL 1971 TRIP ATTRACTIONS	ESTIMATION ERROR			
				MODEL 7		MODEL 8	
	MODEL 7	MODEL 8		TRIPS	%	TRIPS	%
137	215	151	79	136	172	72	91
221	300	251	135	165	122	116	85
262	204	135	75	129	172	60	80
272	387	339	148	239	161	191	129
363	531	695	439	92	20	256	58
394	546	691	470	76	16	221	47
395	410	491	405	5	1	86	21
401	466	519	291	175	60	228	78
477	280	217	159	121	76	58	36
494	380	377	348	32	9	29	8
495	228	164	75	153	204	89	118
511	254	204	189	65	34	15	7
632	303	242	147	156	106	95	64
634	229	169	81	148	182	88	108
651	269	225	137	132	96	88	64
782	340	294	107	233	217	187	174
783	313	287	293	20	6	-6	-2
843	662	924	593	69	11	331	55
844	391	364	131	260	198	233	177
851	383	442	288	95	32	154	53
852	576	754	496	80	16	258	52
862	282	270	230	52	22	40	17
863	811	1180	468	343	73	712	152
892	430	524	226	204	90	298	131
TOTALS	9190	9909	6010	3180	52	3911	65

TABLE 6.8

COMPARISON OF PEAK HOUR CHOICE VEHICULAR WORK TRIP ATTRACTIONS AS ESTIMATED BY MODEL 9 AND MODEL 10

ZONE NUMBER	ESTIMATED 1971 PEAK HOUR CHOICE ATTRACTIONS		ACTUAL 1971 TRIP ATTRACTIONS	ESTIMATION ERROR			
				MODEL 9		MODEL 10	
	MODEL 9	MODEL 10		TRIPS	%	TRIPS	%
137	190	116	71	119	167	45	63
221	244	198	113	131	115	85	75
262	183	104	61	122	200	43	70
272	299	271	125	174	139	146	116
363	390	595	393	-3	0	202	51
394	400	592	432	-32	-7	160	37
395	314	417	368	-54	-14	49	13
401	349	440	258	91	35	182	70
477	231	174	131	100	76	43	32
494	295	296	221	74	33	75	33
495	198	127	55	143	260	72	130
511	215	158	144	71	49	14	9
632	246	192	113	133	117	79	69
634	199	131	62	137	220	69	111
651	224	175	119	105	88	56	47
782	269	234	97	172	177	137	141
783	252	233	260	-8	-3	-27	-10
843	473	799	544	-71	-13	255	46
844	302	302	114	188	164	188	164
851	296	373	268	28	10	105	39
852	418	642	447	-29	-6	195	43
862	232	222	209	23	11	13	6
863	567	1024	429	138	32	595	138
892	326	446	198	128	64	248	125
TOTALS	7112	8261	5232	2274	43	3083	58

TABLE 6.9

COMPARISON OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP ATTRACTIONS AS ESTIMATED BY MODEL 11 AND MODEL 12

ZONE NUMBER	ESTIMATED 1971 PEAK HOUR CAPTIVE ATTRACTIONS		ACTUAL 1971 TRIP ATTRACTIONS	ESTIMATION ERROR			
				MODEL 11		MODEL 12	
	MODEL 11	MODEL 12		TRIPS	%	TRIPS	%
137	25	35	8	17	212	27	337
221	56	53	22	34	154	31	140
262	21	32	14	7	50	18	128
272	88	67	23	65	282	44	191
363	141	99	46	95	206	53	115
394	146	98	38	108	284	60	157
395	97	74	37	60	162	37	100
401	117	79	33	84	254	46	139
477	49	43	28	21	75	15	53
494	86	81	127	-41	-32	-46	-36
495	30	37	20	10	50	17	85
511	39	46	45	-6	-13	1	2
632	57	50	34	23	67	16	47
634	30	39	19	11	57	20	105
651	45	50	18	27	150	32	177
782	71	61	10	61	610	51	510
783	61	55	33	28	84	22	66
843	189	125	49	140	285	76	155
844	90	62	17	73	429	45	264
851	86	69	20	66	330	49	245
852	157	112	49	108	220	63	128
862	49	48	21	28	133	27	128
863	243	155	39	204	523	116	297
892	104	78	28	76	271	50	178
TOTALS	2077	1648	778	1393	179	962	123

the individual zonal attraction levels by as much as six times the actual value.

In summary, none of the models has been shown to forecast the measured zonal attraction levels accurately. The forecasts are considered totally unacceptable and preclude any statement regarding the relative performance of individual trip attraction models.

Summary

This Chapter has attempted to simulate the forecasting process by calibrating six production models and six attraction models to data corresponding to traffic zones developed prior to 1961, and then using these models to forecast the production and attraction levels for zones developed between 1961 and 1971.

Two kinds of models have been considered: (i) models which base their forecasting ability on variables such as population, dwelling units, car ownership and employment and (ii) models which relate trip generation directly to residential and non-residential land development subdivided into various land use categories. The intent of this Chapter was to compare the performance of these two kinds of models when used to forecast peak hour vehicular work trip productions and attractions within the following three groups: (i) total trips (ii) choice trips and (iii) captive trips.

None of the trip production models performed acceptably. Although both MODELS 1 and 2 accurately reproduced the total trip productions for the combined 37 forecast zones, the individual zone forecasts deviated from the actual values by an average of 15%. MODELS 3 and 4 underestimated the choice trip productions by an average of 17% and consequently MODELS 5 and 6 grossly overestimated the captive trips by more than 50%.

Overall, the three production models which relate trip production directly to residential land development (MODELS 2, 4 and 6) performed slightly better than the three which base their forecasts on population, dwelling units and car ownership. It should be noted that the population, dwelling unit and car ownership levels used in MODELS 1, 3 and 5 were projected from 1961 to 1971 using land use based equations similar to the trip production equations used in MODELS 2, 4 and 6.

None of the trip attraction models performed acceptably. All models grossly overestimated both the total attractions for the combined 24 zones within each of the three groups of trips, as well as the individual zonal forecasts. Much of this overestimation can be explained by the fact that the structure of the 24 zones developed between 1961 and 1971 is considerably different to the structure of the zones used to calibrate the models. All 24 zones are situated on the periphery of the City and therefore contain no central area office development; also, there is no university-college development within these zones. Consequently all non-residential development falls within the remaining three categories: industrial, commercial and institutional. These three categories have low trip attraction rates per acre and also are the categories whose partial regression coefficients have the least significance and hence the greatest error. The low trip attraction rates result in the intercept term contributing a significant portion of any estimate made by the models; the high standard errors of the regression coefficients result in high errors in that portion of the estimate attributable to the land usage. This explanation applies to both kinds of models within the context of this comparison since the employment projections used in the employment based attraction models were estimated from a land use based equation.

The foregoing provides an explanation for the inaccuracies in the attraction estimates but does not provide a solution to the underlying problem of calibrating models to zones of one structure and then applying these models to zones of a different structure. Since this problem is not an exclusive function of the simulated forecasting experiment, but a realistic one that is likely to be encountered in the actual forecasting process, Chapter VII discusses some possible ways of overcoming it.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The objective of this thesis has been to develop appropriate trip generation models for use in forecasting future travel patterns in Edmonton.

Chapter II has reviewed the kinds of trip generation models that have been employed previously in Edmonton and elsewhere in North America, and Chapter IV has presented the results of verifying and calibrating these kinds of models to data collected in Edmonton in 1971.

All of these models were shown to fit the 1971 data extremely well. However, these kinds of models base their ability to forecast trip generation levels on variables such as population, dwelling units, car ownership and employment, all of which are as difficult to forecast to some point in the future as trip generation itself. This dependency on variables that are difficult to forecast is considered to be a major disadvantage of these kinds of models.

Chapter V has presented a set of models which relate trip generation to residential and non-residential land development. These models also were verified and calibrated to data collected in Edmonton in 1971 and were shown to have several advantages as follows:

(i) people living within different categories of residential land development as well as people working in different categories of non-residential land development were shown to exhibit significantly different work trip-making behaviour. In other words, the city-wide population cannot be considered a homogeneous group with respect to work trip-making; homogeneity is an assumption that is implicit in certain of the population and employment based models developed in Chapter IV. It can be concluded that although the land use categories selected for the development of land use based models may not be the most appropriate, this form of categorization recognizes and takes into account the non-homogeneity of the work trip-making population.

(ii) the models which relate trip generation to the quantities of various categories of land use obviate the need for a separate process for forecasting the zonal levels of population, dwelling units, car ownership and employment. In fact, as a by-product of the land use based models, equations were developed relating variables such as population and employment to the same quantities of the various land uses. In addition, land use based models are considerably more compatible with the methods currently employed in Edmonton for the preliminary design of proposed residential and non-residential land development and, as a consequence, land use information can be obtained at a very early stage in the design process. Land use based models, therefore, have a definite advantage over population and employment based models since they not only eliminate the dependency on variables that are difficult to forecast but also allow proposed developments and redevelopments to be evaluated from a transportation viewpoint at a much earlier stage in the process.

Chapter VI simulated the forecasting process by calibrating population and employment based models of the kind developed in Chapter IV, and land use based models of the kind developed in Chapter V, to data corresponding to traffic zones developed prior to 1961, and then using these models to forecast the production and attraction levels for zones developed between 1961 and 1971. This process allowed the forecast productions and attractions to be compared with the actual values measured in 1971.

This experiment showed that the land use based production models performed better than the population based models, although none of the models predicted the zonal production levels accurately.

Comparing the trip attraction models within the simulated forecasting experiment produced disappointing results. None of the models was able to predict accurately the combined attraction levels for all zones and in addition the individual zonal attraction levels were overestimated in some instances by a factor of six times the actual values.

The experiment did, however, identify the major cause of these poor results. It is considered that the underlying problem is that of calibrating models to zones of one structure and then applying these models to zones having a substantially different structure. This problem is not considered to be an exclusive function of the simulated forecasting experiment but a realistic one which is very likely to be encountered in the actual forecasting process.

It is recommended, therefore, that future research investigate possible solutions to this problem and the following points are offered as a guide to such research:

(a) The characteristics of new non-residential zones are those of low employment density, the development being predominantly industrial, commercial or institutional. Consequently, when using the land use based models in their present form, the intercept term of each equation contributes a major portion of any estimate and the remaining portion of the estimate, contributed by the land usage, has a high degree of error since the coefficients of the predominant land use categories within the new zones have low levels of significance. This situation stresses the need for accurate land use data with which to calibrate the models; accurate data could increase the reliability of the coefficients and may reduce the magnitude of the intercepts.

(b) Separate models could be developed based on zones containing only industrial, commercial and institutional land development. These models would be more applicable to newly developed non-residential zones. An extension of this approach would be to develop a separate model for each of the land use categories; different sets of categories also could be considered. This approach, however, would require that trip end data be categorized according to the destination land use rather than by the destination traffic zone.

(c) With the varying size of traffic zones, together with the concentration of a large portion of the employment into a few of these traffic zones, employment and trip attraction levels typically range from extremely low values to extremely high values with noticeable gaps in the middle of this range. By expressing the quantities of the various land uses as a fraction of the total developed land within each zone, the effects of varying zone size can be removed completely. This approach might reduce the magnitude of the intercepts and may increase the reliability of the coefficients.

The above suggestions might also improve the accuracy of trip production estimates for newly developed zones although the problem appears to be less prevalent with the production models.

Other methods are available to reduce the inaccuracies associated with production and attraction estimates for redeveloped, as opposed to newly developed, zones. One method involves the adjustment of the coefficients associated with each land use category so that the intercept term is substantially reduced or even removed completely. This method is applied to each existing zone in turn, resulting in a separate set of equations for each traffic zone which exactly reproduce the data used for calibration. When making individual zonal forecasts, any redevelopment that has occured in that zone is assumed to have similar characteristics to existing development within the corresponding land use category. This assumption of zonal homogeneity within each land use category is considered more realistic than one of city-wide homogeneity.

The question of stability of coefficients over time has not yet been addressed. All models developed in this thesis have been calibrated to 1971 data and the coefficients relate to that point in time only. The final recommendation of this thesis is that these models be recalibrated to data collected in 1976 and an analysis be made of the changes that have occured in the coefficients during this five year period. Such an analysis may allow the enhancement of these trip generation models by the inclusion of a time adjustment factor for each coefficient.

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APPENDIX A

DEMOGRAPHIC, TRIP END AND LAND USE DATA
FOR EDMONTON (1971)
AS USED IN TRIP GENERATION ANALYSES

TABLE A.1

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	11	12	13	14	21	22	31	32
POPULATION PER ZONE	122	14	550	200	613	3382	1216	970
DWELLINGS PER ZONE	90	13	466	115	423	1830	787	499
CARS PER ZONE	18	3	68	18	100	1054	172	139
LABOUR FORCE PER ZONE	42	12	209	62	402	2121	329	190
EMPLOYMENT PER ZONE	2279	3976	3740	6148	7108	840	7310	9641
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	10	0	33	11	64	459	34	72
PEAK HOUR CHOICE PRODUCTION	3	0	9	7	35	259	20	49
PEAK HOUR CAPTIVE PRODUCTION	7	0	24	4	29	200	14	23
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	1380	1865	2110	2906	5190	415	4010	5410
PEAK HOUR CHOICE ATTRACTION	965	1176	1424	1768	3447	302	2837	3330
PEAK HOUR CAPTIVE ATTRACTION	415	689	686	1138	1743	113	1173	2080
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.76
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.36	7.53	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.07	0.17	12.16	33.57	4.91	0.19
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	12.65	18.66	30.31	2.66	1.38	15.52	25.44
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.56
INDUSTRIAL	20.78	13.32	9.49	1.38	0.0	9.47	0.0	0.0
COMMERCIAL	0.0	0.0	0.92	0.0	1.22	0.0	2.90	0.15
INSTITUTIONAL	4.12	0.0	1.34	1.64	44.05	13.41	10.86	6.12

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	41	42	44	45	46	51	52	53
POPULATION PER ZONE	0	0	0	3947	334	0	0	3337
DWELLINGS PER ZONE	0	0	1	1524	164	0	0	1086
CARS PER ZONE	0	0	0	1072	63	0	0	1065
LABOUR FORCE PER ZONE	0	0	0	1876	171	0	0	1315
EMPLOYMENT PER ZONE	10	74	362	376	236	769	3201	1495
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	0	0	0	674	70	0	0	533
PEAK HOUR CHOICE PRODUCTION	0	0	0	392	22	0	0	381
PEAK HOUR CAPTIVE PRODUCTION	0	0	0	282	48	0	0	152
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	7	35	210	203	70	494	1570	576
PEAK HOUR CHOICE ATTRACTION	5	31	180	177	47	415	1100	438
PEAK HOUR CAPTIVE ATTRACTION	2	4	30	26	23	79	470	138
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	0.0	76.07	0.0	0.0	0.0	93.03
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	0.0	32.95	3.96	0.72	0.0	25.33
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	26.46	0.0
INDUSTRIAL	0.0	44.57	0.0	0.0	0.0	7.39	0.0	4.86
COMMERCIAL	0.0	0.0	0.0	1.30	5.00	0.0	0.0	22.10
INSTITUTIONAL	0.0	0.0	15.17	6.43	0.0	110.82	0.0	28.51

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	54	55	56	61	62	63	64	71
POPULATION PER ZONE	0	2	1801	4	6759	6	52	4299
DWELLINGS PER ZONE	0	1	569	1	2746	2	12	2018
CARS PER ZONE	0	1	670	3	2434	3	10	1294
LABOUR FORCE PER ZONE	0	0	713	4	3473	3	20	2470
EMPLOYMENT PER ZONE	287	836	622	885	917	205	1086	4344
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	0	0	396	1	1710	2	3	977
PEAK HOUR CHOICE PRODUCTION	0	0	302	1	1011	1	2	569
PEAK HOUR CAPTIVE PRODUCTION	0	0	94	0	699	1	1	408
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	128	638	293	695	473	144	698	1596
PEAK HOUR CHOICE ATTRACTION	95	530	214	524	376	125	617	1130
PEAK HOUR CAPTIVE ATTRACTION	33	108	79	171	97	19	81	466
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	45.78	0.0	59.05	0.0	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	8.16	0.0	62.77	0.0	0.0	34.41
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	27.39	0.0	0.0	45.62
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.17
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	54.70	0.0	35.54	0.0	15.78	30.04	0.0
COMMERCIAL	10.21	0.0	13.75	0.0	8.68	0.0	0.0	14.90
INSTITUTIONAL	0.0	2.22	12.61	0.97	16.77	2.55	0.0	20.72

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	72	73	81	82	83	84	85	86
POPULATION PER ZONE	2772	157	0	0	27	4571	4342	3459
DWELLINGS PER ZONE	1208	59	0	0	6	1536	1466	1052
CARS PER ZONE	306	15	0	0	5	1372	1326	1099
LABOUR FORCE PER ZONE	663	30	0	0	6	1451	1544	1240
EMPLOYMENT PER ZONE	1664	951	274	383	148	366	490	425
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	212	6	0	0	1	676	730	570
PEAK HOUR CHOICE PRODUCTION	92	2	0	0	0	483	517	395
PEAK HOUR CAPTIVE PRODUCTION	120	4	0	0	1	193	213	175
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	899	535	183	206	74	176	216	152
PEAK HOUR CHOICE ATTRACTION	717	428	161	183	64	144	165	120
PEAK HOUR CAPTIVE ATTRACTION	182	107	22	23	10	32	51	32
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	125.71	130.90	107.91
MEDIUM DENSITY RESIDENTIAL	35.14	0.0	0.0	0.0	0.0	20.79	28.69	15.70
HIGH DENSITY RESIDENTIAL	0.0	1.79	0.0	0.0	0.0	0.0	0.0	0.26
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	9.77	31.73	29.84	32.19	29.02	0.0	2.64	3.57
COMMERCIAL	13.82	0.0	0.0	0.0	0.90	6.36	5.26	8.24
INSTITUTIONAL	4.71	0.0	0.0	0.0	0.0	2.54	8.90	5.28

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	87	91	92	93	101	102	103	104
POPULATION PER ZONE	17	5484	4429	656	3664	304	413	2271
DWELLINGS PER ZONE	4	1884	1377	209	994	83	152	958
CARS PER ZONE	4	1265	1111	169	555	61	130	760
LABOUR FORCE PER ZONE	5	1681	1346	211	846	78	183	1165
EMPLOYMENT PER ZONE	1129	557	672	149	516	229	982	122
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR PRODUCTION	2	734	580	58	296	19	90	582
PEAK HOUR CHOICE PRODUCTION	1	445	375	35	141	18	55	377
PEAK HOUR CAPTIVE PRODUCTION	1	289	205	23	155	1	35	205
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR ATTRACTION	407	254	323	76	279	110	520	42
PEAK HOUR CHOICE ATTRACTION	343	209	252	52	232	87	312	29
PEAK HOUR CAPTIVE ATTRACTION	64	45	71	24	47	23	208	13
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	103.94	99.92	15.23	0.0	5.33	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	33.24	19.56	7.26	59.48	4.12	0.96	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	2.22	0.0	6.50	23.31
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	71.22	0.0	3.35	5.51	4.52	0.0	22.55	1.44
COMMERCIAL	0.0	9.05	3.99	1.81	4.09	2.23	0.0	0.05
INSTITUTIONAL	10.16	14.10	3.62	3.64	11.04	2.74	0.19	3.64

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	105	106	111	112	113	114	115	116
POPULATION PER ZONE	2915	1249	524	3576	1620	232	954	1137
DWELLINGS PER ZONE	1277	425	163	1138	524	88	350	361
CARS PER ZONE	520	313	141	1128	652	76	321	429
LABOUR FORCE PER ZONE	876	358	173	1213	651	64	316	338
EMPLOYMENT PER ZONE	395	86	140	214	88	713	48	78
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR PRODUCTION	309	159	96	581	303	39	174	179
PEAK HOUR CHOICE PRODUCTION	169	94	77	428	228	31	127	139
PEAK HOUR CAPTIVE PRODUCTION	140	65	19	153	75	8	47	40
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR ATTRACTION	201	46	76	90	25	371	20	34
PEAK HOUR CHOICE ATTRACTION	143	33	65	76	23	265	14	27
PEAK HOUR CAPTIVE ATTRACTION	58	13	11	14	2	106	6	7
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	17.87	39.26	12.08	151.67	76.47	11.93	32.20	53.67
MEDIUM DENSITY RESIDENTIAL	0.53	0.0	5.06	3.73	1.59	0.0	9.32	3.84
HIGH DENSITY RESIDENTIAL	35.36	6.75	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.84
INDUSTRIAL	2.31	0.0	9.15	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	7.62	0.38	0.27	2.62	0.0	0.0	0.44	1.06
INSTITUTIONAL	7.13	5.69	2.69	21.12	6.38	0.18	4.84	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	121	122	123	124	125	126	131	132
POPULATION PER ZONE	134	677	11	903	693	5401	973	4815
DWELLINGS PER ZONE	49	201	4	221	213	1527	229	1261
CARS PER ZONE	39	201	0	242	198	1618	305	1424
LABOUR FORCE PER ZONE	39	173	2	247	182	1705	259	1484
EMPLOYMENT PER ZONE	242	1185	1024	26	91	220	40	416
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR PRODUCTION	18	74	1	117	70	791	122	710
PEAK HOUR CHOICE PRODUCTION	14	57	0	83	59	572	103	529
PEAK HOUR CAPTIVE PRODUCTION	4	17	1	34	11	219	19	181
		(peak hour vehicular work trips only)						
TOTAL PEAK HOUR ATTRACTION	139	461	304	10	27	73	19	117
PEAK HOUR CHOICE ATTRACTION	119	417	249	9	19	57	17	99
PEAK HOUR CAPTIVE ATTRACTION	20	44	55	1	8	16	2	18
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	15.92	0.0	21.32	13.46	173.44	31.28	152.32
MEDIUM DENSITY RESIDENTIAL	0.0	1.72	0.0	0.0	2.28	11.35	0.0	2.71
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	53.51	62.83	13.40	0.0	0.0	0.0	1.14	0.0
COMMERCIAL	0.0	0.86	0.0	0.0	0.69	3.99	0.0	7.45
INSTITUTIONAL	0.0	0.0	0.0	0.28	0.33	20.28	0.53	8.15

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	133	134	135	137	191	192	201	202
POPULATION PER ZONE	12	3456	1487	2573	2959	4757	4954	192
DWELLINGS PER ZONE	4	927	357	641	711	1088	1331	58
CARS PER ZONE	5	1132	421	838	1013	1454	1437	59
LABOUR FORCE PER ZONE	4	1150	391	813	921	1331	1420	56
EMPLOYMENT PER ZONE	12	181	64	150	71	87	205	16
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	3	517	193	443	537	703	630	12
PEAK HOUR CHOICE PRODUCTION	3	375	150	356	425	604	507	8
PEAK HOUR CAPTIVE PRODUCTION	0	142	43	87	112	99	123	4
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	4	72	33	79	28	29	56	4
PEAK HOUR CHOICE ATTRACTION	4	60	28	71	23	24	47	4
PEAK HOUR CAPTIVE ATTRACTION	0	12	5	8	5	5	9	0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	111.69	39.39	86.35	121.89	131.01	150.46	0.0
MEDIUM DENSITY RESIDENTIAL	18.00	1.74	1.40	3.67	0.0	26.90	16.79	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	5.00	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.03
COMMERCIAL	0.0	6.61	2.51	0.0	0.0	0.0	6.56	0.0
INSTITUTIONAL	4.70	15.43	4.65	6.00	17.16	11.41	19.99	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	203	211	212	221	222	223	261	262
POPULATION PER ZONE	74	5863	5672	5204	3688	30	1876	2582
DWELLINGS PER ZONE	25	1340	1458	1315	920	8	456	653
CARS PER ZONE	21	1905	1726	1795	1160	12	583	896
LABOUR FORCE PER ZONE	20	1765	1771	1705	1185	13	592	857
EMPLOYMENT PER ZONE	84	116	476	302	80	56	94	160
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	7	896	828	916	609	7	354	475
PEAK HOUR CHOICE PRODUCTION	6	739	662	743	495	6	282	384
PEAK HOUR CAPTIVE PRODUCTION	1	157	166	173	114	1	72	91
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	35	45	159	135	31	37	44	75
PEAK HOUR CHOICE ATTRACTION	30	33	125	113	28	34	37	61
PEAK HOUR CAPTIVE ATTRACTION	5	12	34	22	3	3	7	14
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	200.05	182.71	141.77	107.68	0.94	129.38	91.47
MEDIUM DENSITY RESIDENTIAL	0.0	3.33	18.14	35.68	16.21	0.0	25.42	15.93
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	7.30	0.0	18.31	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	2.58	1.11	3.58	3.09	0.0	0.0	0.0	0.0
INSTITUTIONAL	0.0	14.20	41.72	33.40	9.13	0.0	9.98	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	271	272	273	274	281	282	283	284
POPULATION PER ZONE	0	4937	2404	3834	4522	1072	2715	0
DWELLINGS PER ZONE	0	1225	741	1048	1111	303	759	0
CARS PER ZONE	0	1628	836	1152	1425	410	913	0
LABOUR FORCE PER ZONE	0	1648	876	1209	1339	408	958	0
EMPLOYMENT PER ZONE	15	307	239	279	1247	77	349	1588
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	0	869	431	609	640	203	463	0
PEAK HOUR CHOICE PRODUCTION	0	693	328	441	518	150	332	0
PEAK HOUR CAPTIVE PRODUCTION	0	176	103	168	122	53	131	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	5	148	112	99	394	31	114	573
PEAK HOUR CHOICE ATTRACTION	5	125	95	81	330	27	94	492
PEAK HOUR CAPTIVE ATTRACTION	0	23	17	18	64	4	20	81
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.17	124.05	66.62	81.26	163.19	46.10	83.76	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	30.19	7.99	17.18	23.33	1.29	9.33	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.48	0.0	0.0	0.0	31.51
COMMERCIAL	25.60	9.32	10.49	6.06	15.14	0.05	8.85	0.0
INSTITUTIONAL	0.0	42.75	18.74	6.69	27.31	5.79	6.97	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	321	322	323	324	331	332	333	363
POPULATION PER ZONE	2812	2811	3180	2153	284	5292	2985	18
DWELLINGS PER ZONE	708	666	904	603	64	1205	735	6
CARS PER ZONE	950	884	1003	623	75	1640	873	7
LABOUR FORCE PER ZONE	931	845	1023	671	80	1604	908	7
EMPLOYMENT PER ZONE	177	106	195	119	127	186	148	669
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	505	416	519	346	44	842	477	4
PEAK HOUR CHOICE PRODUCTION	411	349	386	252	36	653	383	4
PEAK HOUR CAPTIVE PRODUCTION	94	67	133	94	8	189	94	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	54	43	78	41	69	73	73	439
PEAK HOUR CHOICE ATTRACTION	49	36	69	31	61	64	59	393
PEAK HOUR CAPTIVE ATTRACTION	5	7	9	10	8	9	14	46
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	95.59	82.88	101.16	87.04	14.56	139.93	86.32	0.0
MEDIUM DENSITY RESIDENTIAL	1.13	5.10	6.89	0.93	0.0	16.90	18.79	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	2.68	0.0	38.63	0.0	0.19	97.04
COMMERCIAL	8.61	1.69	2.56	0.72	0.0	1.22	2.94	0.0
INSTITUTIONAL	11.98	2.60	1.99	12.40	16.83	24.01	16.80	6.64

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	393	394	395	396	401	402	403	404
POPULATION PER ZONE	43	0	0	0	0	9	0	37
DWELLINGS PER ZONE	13	0	0	0	0	3	0	7
CARS PER ZONE	19	0	0	0	0	3	0	10
LABOUR FORCE PER ZONE	11	0	0	0	0	6	0	6
EMPLOYMENT PER ZONE	141	718	572	62	522	157	2075	345
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	3	0	0	0	0	4	0	4
PEAK HOUR CHOICE PRODUCTION	3	0	0	0	0	2	0	4
PEAK HOUR CAPTIVE PRODUCTION	0	0	0	0	0	2	0	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	74	470	405	33	291	109	1471	234
PEAK HOUR CHOICE ATTRACTION	68	432	368	29	258	91	1258	194
PEAK HOUR CAPTIVE ATTRACTION	6	38	37	4	33	18	213	40
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	0.29	0.0	0.15	0.0	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	23.36	92.74	63.53	7.36	54.93	18.36	185.57	43.10
COMMERCIAL	0.0	3.61	0.0	0.0	7.42	0.0	1.10	0.0
INSTITUTIONAL	0.0	0.0	0.0	0.0	0.0	0.0	0.66	14.28

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	405	406	411	412	413	414	415	416
POPULATION PER ZONE	0	356	3534	2888	0	0	1327	779
DWELLINGS PER ZONE	0	123	897	793	0	0	594	221
CARS PER ZONE	0	159	1273	1039	0	0	482	284
LABOUR FORCE PER ZONE	0	113	1215	1121	0	0	706	318
EMPLOYMENT PER ZONE	1991	579	201	503	250	495	32	171
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	0	65	641	594	0	0	358	171
PEAK HOUR CHOICE PRODUCTION	0	50	522	434	0	0	235	125
PEAK HOUR CAPTIVE PPODUCTION	0	15	119	160	0	0	123	46
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	1360	321	106	307	56	93	21	77
PEAK HOUR CHOICE ATTRACTION	1153	295	80	171	46	80	17	55
PEAK HOUR CAPTIVE ATTPACTION	207	26	26	136	10	13	4	22
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	144.92	97.00	1.36	0.0	0.0	32.70
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	8.50	14.12	9.02	1.85	28.08	3.24
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	203.69	44.52	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.51	21.27	3.84	0.95	0.0	35.42	0.0	0.0
INSTITUTIONAL	10.43	0.93	17.42	11.94	9.02	0.73	0.0	8.48

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	421	422	423	424	431	432	433	434
POPULATION PER ZONE	152	254	3987	2088	1343	3903	1935	2676
DWELLINGS PER ZONE	43	78	1086	599	489	1610	596	958
CARS PER ZONE	34	72	1342	660	450	1387	676	869
LABOUR FORCE PER ZONE	38	79	1369	654	516	1839	728	1067
EMPLOYMENT PER ZONE	329	203	164	627	558	202	200	605
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	20	30	622	345	216	978	434	516
PEAK HOUR CHOICE PRODUCTION	18	26	503	247	168	628	314	337
PEAK HOUR CAPTIVE PRODUCTION	2	4	119	98	48	350	120	179
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	168	143	78	268	162	91	108	308
PEAK HOUR CHOICE ATTRACTION	156	126	71	222	113	75	85	259
PEAK HOUR CAPTIVE ATTRACTION	12	17	7	46	49	16	23	49
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.49	133.91	92.09	33.92	94.65	77.25	66.20
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	16.19	0.0	7.56	8.39	6.64	6.97
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	19.81	0.0	6.52
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	33.57	15.38	0.0	3.61	0.0	0.0	0.0	0.0
COMMERCIAL	0.52	0.0	2.89	5.28	1.16	4.46	0.0	7.64
INSTITUTIONAL	0.52	0.0	11.48	14.71	25.48	6.50	4.82	1.33

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	441	442	443	444	451	452	453	454
POPULATION PER ZONE	592	4487	802	2733	1838	7	2564	429
DWELLINGS PER ZONE	178	1971	473	1492	893	6	1386	251
CARS PER ZONE	219	1686	305	1144	656	4	941	104
LABOUR FORCE PER ZONE	206	2353	352	1505	1113	3	1408	216
EMPLOYMENT PER ZONE	20	1927	426	726	301	247	932	1122
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	97	1213	169	836	516	2		
PEAK HOUR CHOICE PRODUCTION	72	780	97	533	302	2	632	60
PEAK HOUR CAPTIVE PRODUCTION	25	433	72	303	214	0	412	37
							220	23
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	8	1051	196	312	189	172		
PEAK HOUR CHOICE ATTRACTION	7	863	140	224	152	122	483	424
PEAK HOUR CAPTIVE ATTRACTION	1	188	56	88	37	50	357	259
							126	165
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	26.93	29.49	6.50	0.0	0.0	0.0	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	2.60	5.21	3.90	0.0	0.0	0.0	0.20	0.0
HIGH DENSITY RESIDENTIAL	0.0	52.44	2.96	28.88	17.48	0.0	23.02	5.09
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.10
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	16.20	0.0	0.0	0.0	26.73	0.0	3.44
COMMERCIAL	0.0	11.94	2.38	2.79	5.35	0.0	5.96	0.0
INSTITUTIONAL	0.46	8.76	0.86	2.12	0.0	0.52	1.10	4.92

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	455	461	462	463	464	465	471	472
POPULATION PER ZONE	2640	2424	2826	3002	3215	1003	3613	2607
DWELLINGS PER ZONE	1406	708	829	944	1073	300	865	652
CARS PER ZONE	1019	835	1101	1168	1390	479	1204	900
LABOUR FORCE PER ZONE	1125	833	1082	1036	1334	343	1135	769
EMPLOYMENT PER ZONE	136	282	194	233	224	46	121	101
(peak hour vehicular work trips only)								
TOTAL PEAK HOUR PRODUCTION	490	426	602	547	697	127	616	389
PEAK HOUR CHOICE PRODUCTION	356	355	501	424	536	97	486	297
PEAK HOUR CAPTIVE PRODUCTION	134	71	101	123	161	30	130	92
(peak hour vehicular work trips only)								
TOTAL PEAK HOUR ATTRACTION	56	115	69	107	83	27	55	31
PEAK HOUR CHOICE ATTRACTION	44	94	52	95	73	21	45	24
PEAK HOUR CAPTIVE ATTPACTION	12	21	17	12	10	6	10	7
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	80.10	122.35	143.33	179.26	60.95	109.07	94.65
MEDIUM DENSITY RESIDENTIAL	0.0	6.73	5.26	0.0	0.0	0.0	3.78	0.21
HIGH DENSITY RESIDENTIAL	37.52	0.0	0.0	0.0	2.10	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.0	4.82	0.52	2.92	1.85	0.25	3.57	6.65
INSTITUTIONAL	4.90	32.30	6.69	7.61	16.00	13.68	12.53	3.79

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	473	474	475	476	477	478	479	491
POPULATION PER ZONE	1398	2699	2664	0	142	884	1640	1954
DWELLINGS PER ZONE	342	707	774	0	38	246	688	546
CARS PER ZONE	489	926	843	0	47	268	451	664
LABOUR FORCE PER ZONE	429	812	842	0	41	245	593	700
EMPLOYMENT PER ZONE	34	112	105	34	354	292	601	191
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	236	419	419	0	20	111	230	349
PEAK HOUR CHOICE PRODUCTION	203	359	322	0	16	91	152	276
PEAK HOUR CAPTIVE PRODUCTION	33	60	97	0	4	20	78	73
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	19	47	56	7	159	106	183	83
PEAK HOUR CHOICE ATTRACTION	14	39	47	6	131	100	152	64
PEAK HOUR CAPTIVE ATTRACTION	5	8	9	1	28	6	31	19
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	41.47	94.05	95.38	0.28	0.96	33.95	5.62	59.41
MEDIUM DENSITY RESIDENTIAL	1.43	5.80	7.44	0.0	0.0	1.38	22.41	10.90
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.34	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	4.83	0.0	0.0	9.87
COMMERCIAL	1.77	0.49	1.19	20.69	5.34	17.57	12.69	3.00
INSTITUTIONAL	5.85	11.03	8.07	0.0	0.0	1.85	4.43	49.97

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	492	493	494	495	496	497	501	502
POPULATION PER ZONE	2422	2936	3883	4031	4511	0	3686	1124
DWELLINGS PER ZONE	665	928	911	909	1252	0	1024	287
CARS PER ZONE	797	923	1336	1327	1489	0	1588	582
LABOUR FORCE PER ZONE	738	946	1322	1224	1371	0	1326	391
EMPLOYMENT PER ZONE	63	56	1034	252	240	234	157	30
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	372	458	747	678	698	0	792	237
PEAK HOUR CHOICE PRODUCTION	274	347	621	567	538	0	647	220
PEAK HOUR CAPTIVE PRODUCTION	98	111	126	111	160	0	145	17
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	22	24	348	75	88	48	58	7
PEAK HOUR CHOICE ATTRACTION	20	18	221	55	67	38	45	5
PEAK HOUR CAPTIVE ATTRACTION	2	6	127	20	21	10	13	2
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	94.37	97.45	95.56	143.07	143.30	1.31	204.64	77.74
MEDIUM DENSITY RESIDENTIAL	4.89	12.68	5.55	0.0	17.12	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.0	1.31	0.0	0.91	6.51	22.87	3.86	0.0
INSTITUTIONAL	5.93	0.34	95.96	7.54	9.04	1.18	24.64	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	503	504	505	506	511	512	513	514
POPULATION PER ZONE	1870	1843	3421	42	5743	1958	1889	2172
DWELLINGS PER ZONE	493	418	815	9	1365	469	488	502
CARS PER ZONE	807	833	1495	19	1808	743	712	848
LABOUR FORCE PER ZONE	666	553	1019	12	1697	621	591	621
EMPLOYMENT PER ZONE	27	36	100	8	647	69	53	59
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	356	268	662	7	883	388	383	431
PEAK HOUR CHOICE PRODUCTION	298	255	579	7	721	331	345	392
PEAK HOUR CAPTIVE PRODUCTION	58	13	83	0	162	57	38	39
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	11	17	33	1	189	28	21	22
PEAK HOUR CHOICE ATTRACTION	10	16	26	1	144	26	16	21
PEAK HOUR CAPTIVE ATTRACTION	1	1	7	0	45	2	5	1
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	79.01	95.81	173.44	0.0	185.16	65.43	88.53	103.30
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	8.25	0.14	13.51	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.0	0.0	2.21	0.0	0.0	0.0	0.0	0.0
INSTITUTIONAL	4.68	0.0	9.46	0.0	27.10	3.84	7.77	5.65

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	515	592	593	595	601	602	603	604
POPULATION PER ZONE	414	97	1315	822	3	1732	20	152
DWELLINGS PER ZONE	90	24	321	188	1	503	8	3
CARS PER ZONE	170	32	463	309	1	792	10	1
LABOUR FORCE PER ZONE	103	15	352	214	3	716	14	2
EMPLOYMENT PER ZONE	4	10	35	19	2	114	20509	714
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	74	11	240	144	0	217	2	0
PEAK HOUR CHOICE PRODUCTION	72	7	209	130	0	197	2	0
PEAK HOUR CAPTIVE PRODUCTION	2	4	31	14	0	20	0	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	0	2	16	11	2	55	7237	319
PEAK HOUR CHOICE ATTRACTION	0	2	16	10	2	41	4568	211
PEAK HOUR CAPTIVE ATTRACTION	0	0	0	1	0	14	2669	108
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	31.56	66.66	53.41	58.04	0.0	118.65	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	8.95	7.98	0.0	0.0	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	130.84	27.63
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.0	0.0	0.0	0.55	0.0	1.52	0.0	0.0
INSTITUTIONAL	0.0	0.0	9.15	2.98	0.0	6.05	0.0	59.03

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	605	611	612	613	622	632	633	634
POPULATION PER ZONE	3256	3402	1553	260	1862	3058	999	2677
DWELLINGS PER ZONE	1276	1062	354	51	509	785	308	619
CARS PER ZONE	1103	1378	669	55	739	1091	300	961
LABOUR FORCE PER ZONE	2313	1601	498	59	630	1076	430	761
EMPLOYMENT PER ZONE	682	222	67	132	86	822	5	234
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	241	674	340	29	384	627	228	497
PEAK HOUR CHOICE PRODUCTION	187	520	299	24	320	511	144	453
PEAK HOUR CAPTIVE PRODUCTION	54	154	41	5	64	116	84	44
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	228	129	24	75	33	147	2	81
PEAK HOUR CHOICE ATTRACTION	160	100	19	66	27	113	2	62
PEAK HOUR CAPTIVE ATTRACTION	68	29	5	9	6	34	0	19
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	45.42	182.35	101.83	0.0	87.95	106.88	0.0	108.84
MEDIUM DENSITY RESIDENTIAL	0.0	7.04	0.70	2.09	20.66	7.64	0.0	0.0
HIGH DENSITY RESIDENTIAL	24.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	1.58	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	3.69	0.22	1.41	0.0	0.0	5.67	0.0	0.0
INSTITUTIONAL	4.15	16.41	15.06	43.10	9.54	19.29	0.0	13.46

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	641	651	652	653	654	681	682	683
POPULATION PER ZONE	3446	4536	1711	511	5022	3022	2703	0
DWELLINGS PER ZONE	764	1253	419	108	1156	906	675	0
CARS PER ZONE	1435	1729	649	74	1819	1192	953	0
LABOUR FORCE PER ZONE	960	1657	572	90	1460	1246	896	0
EMPLOYMENT PER ZONE	128	332	113	11	95	196	326	15
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	646	977	320	45	928	635	433	0
PEAK HOUR CHOICE PRODUCTION	581	866	267	30	819	491	371	0
PEAK HOUR CAPTIVE PRODUCTION	65	111	53	15	109	144	62	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	58	137	58	6	38	65	151	4
PEAK HOUR CHOICE ATTRACTION	51	119	49	4	35	58	130	4
PEAK HOUR CAPTIVE ATTRACTION	7	18	9	2	3	7	21	0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	190.84	118.29	60.42	21.62	198.28	138.46	43.75	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	50.36	8.54	0.0	1.39	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	C.0	0.0	0.0	6.44	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	0.0	0.0	0.0	0.0	0.54	3.88	24,36	44.28
INSTITUTIONAL	14.20	35.40	12.27	0.0	20.40	0.19	6.72	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	684	691	692	693	694	695	701	702
POPULATION PER ZONE	2015	3905	4753	3025	2362	1517	50	4397
DWELLINGS PER ZONE	500	1424	1936	943	779	478	14	2043
CARS PER ZONE	596	1428	1662	1088	836	521	13	1696
LABOUR FORCE PER ZONE	615	1956	2168	1290	979	590	16	2881
EMPLOYMENT PER ZONE	92	138	770	124	82	265	150	1648
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	319	520	900	646	409	223	8	872
PEAK HOUR CHOICE PRODUCTION	281	402	593	488	311	185	3	589
PEAK HOUR CAPTIVE PRODUCTION	38	118	307	158	98	38	5	283
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	28	53	369	53	17	144	98	568
PEAK HOUR CHOICE ATTRACTION	25	43	311	42	15	125	76	451
PEAK HOUR CAPTIVE ATTRACTION	3	10	58	11	2	19	22	117
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	30.10	142.30	70.01	115.68	86.88	45.81	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	52.94	7.01	0.0	2.28	0.0	43.06
HIGH DENSITY RESIDENTIAL	8.14	4.03	8.13	0.0	0.0	0.0	0.50	24.97
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	1.94	0.0	0.0	0.0	0.0	2.81	0.0	2.99
COMMERCIAL	0.0	1.23	14.13	1.44	3.68	0.0	0.0	14.21
INSTITUTIONAL	21.02	13.86	19.05	8.68	12.69	7.04	0.0	7.69

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	703	704	711	712	713	714	721	722
POPULATION PER ZONE	3168	3298	59	623	0	19	338	2442
DWELLINGS PER ZONE	1475	1238	43	228	0	8	105	725
CARS PER ZONE	1165	1086	14	190	0	9	99	800
LABOUR FORCE PER ZONE	1683	1517	22	215	0	9	104	888
EMPLOYMENT PER ZONE	445	87	697	632	281	649	73	238
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	751	723	10	97	0	4	42	374
PEAK HOUR CHOICE PRODUCTION	476	434	6	70	0	3	28	273
PEAK HOUR CAPTIVE PRODUCTION	275	289	4	27	0	1	14	101
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	182	39	392	374	180	325	32	66
PEAK HOUR CHOICE ATTRACTION	152	36	332	314	170	277	24	46
PEAK HOUR CAPTIVE ATTRACTION	30	3	60	60	10	48	8	20
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	5.31	66.08	12.98	0.40	29.03	0.0	13.54	111.85
MEDIUM DENSITY RESIDENTIAL	42.65	0.0	0.0	5.57	0.0	0.0	0.0	2.33
HIGH DENSITY RESIDENTIAL	22.11	14.44	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	1.46	0.0	14.59	36.10	19.95	121.87	0.0	0.0
COMMERCIAL	5.67	1.10	19.39	3.83	0.41	0.0	0.0	1.56
INSTITUTIONAL	7.95	0.70	0.0	0.40	14.16	0.0	0.0	29.63

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	723	724	725	731	732	733	741	742
POPULATION PER ZONE	2663	0	2375	754	3373	5241	4	53
DWELLINGS PER ZONE	889	0	765	247	1201	1399	2	13
CARS PER ZONE	945	0	886	240	1173	1764	3	24
LABOUR FORCE PER ZONE	1085	0	941	257	1247	1650	3	16
EMPLOYMENT PER ZONE	260	340	373	138	170	215	135	15
	(peak hour vehicular work trips only)							
TOTAL PEAK HOUR PRODUCTION	562	0	497	121	674	931	3	10
PEAK HOUR CHOICE PRODUCTION	409	0	375	95	477	748	3	9
PEAK HOUR CAPTIVE PRODUCTION	153	0	122	26	197	183	0	1
	(peak hour vehicular work trips only)							
TOTAL PEAK HOUR ATTRACTION	83	81	86	34	50	70	77	7
PEAK HOUR CHOICE ATTRACTION	59	67	71	22	44	54	58	5
PEAK HOUR CAPTIVE ATTRACTION	24	14	15	12	6	16	19	2
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	87.15	0.35	78.10	26.10	98.11	282.76	1.84	0.99
MEDIUM DENSITY RESIDENTIAL	3.00	0.0	10.63	0.0	28.94	10.47	4.79	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMERCIAL	3.07	28.48	3.07	0.29	3.67	0.94	0.0	0.0
INSTITUTIONAL	6.60	1.82	9.70	0.54	12.55	107.92	4.79	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	743	744	745	746	747	748	749	751
POPULATION PER ZONE	2824	2020	1682	1298	1779	0	3	3281
DWELLINGS PER ZONE	899	582	426	354	601	0	1	790
CARS PER ZONE	1037	636	499	462	719	0	1	1288
LABOUR FORCE PER ZONE	1007	732	517	406	736	0	2	1153
EMPLOYMENT PER ZONE	135	139	145	79	120	141	22	143
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	559	365	304	204	397	0	1	704
PEAK HOUR CHOICE PRODUCTION	436	258	240	153	296	0	1	593
PEAK HOUR CAPTIVE PRODUCTION	123	107	64	51	101	0	0	111
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	66	30	38	29	36	19	12	63
PEAK HOUR CHOICE ATTRACTION	47	29	32	23	32	14	11	58
PEAK HOUR CAPTIVE ATTRACTION	19	1	6	6	4	5	1	5
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	100.01	56.88	39.76	46.93	41.55	0.0	0.0	152.79
MEDIUM DENSITY RESIDENTIAL	4.01	1.50	2.58	1.06	0.0	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	6.35	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	4.27	0.0
COMMERCIAL	2.63	12.87	2.99	0.86	4.81	36.67	0.0	2.07
INSTITUTIONAL	3.17	8.76	0.0	25.58	8.89	0.0	0.0	17.48

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	753	754	755	781	782	783	793	821
POPULATION PER ZONE	1971	3312	4133	3290	6197	5524	0	2324
DWELLINGS PER ZONE	471	817	923	820	1486	1440	0	880
CARS PER ZONE	768	1237	1244	1247	2155	1916	0	733
LABOUR FORCE PER ZONE	642	1126	1183	1108	1925	1865	0	958
EMPLOYMENT PER ZONE	21	275	97	217	298	628	121	69
			(peak hour	vehicular	work trips	only)		
TOTAL PEAK HOUR PRODUCTION	421	690	659	659	1117	1001	0	432
PEAK HOUR CHOICE PRODUCTION	349	574	561	531	912	820	0	272
PEAK HOUR CAPTIVE PRODUCTION	72	116	98	128	205	181	0	160
			(peak hour	vehicular	work trips	only)		
TOTAL PEAK HOUR ATTRACTION	7	137	38	69	107	293	48	32
PEAK HOUR CHOICE ATTRACTION	6	120	31	53	97	260	41	18
PEAK HOUR CAPTIVE ATTRACTION	1	17	7	16	10	33	7	14
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	84.78	139.01	123.13	120.22	249.13	179.27	0.0	68.27
MEDIUM DENSITY RESIDENTIAL	0.0	1.33	14.31	4.10	10.44	7.79	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.25
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	13.69	157.86	0.0
COMMERCIAL	0.0	1.06	3.30	1.41	5.29	2.66	0.0	0.78
INSTITUTIONAL	0.0	11.33	24.50	19.19	41.62	19.06	0.0	10.86

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	822	823	824	831	832	833	841	842
POPULATION PER ZONE	2353	1587	3367	473	4280	4652	27	3
DWELLINGS PER ZONE	700	465	881	159	1272	1192	6	2
CARS PER ZONE	738	610	1124	163	1437	1827	7	2
LABOUR FORCE PER ZONE	802	621	1030	176	1569	1570	5	1
EMPLOYMENT PER ZONE	594	208	162	7	219	442	1018	1186
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	367	292	611	91	762	937	1	0
PEAK HOUR CHOICE PRODUCTION	272	234	490	57	571	768	0	0
PEAK HOUR CAPTIVE PRODUCTION	95	58	121	34	191	169	1	0
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	255	79	71	4	91	223	683	868
PEAK HOUR CHOICE ATTRACTION	211	66	58	2	72	190	624	784
PEAK HOUR CAPTIVE ATTRACTION	44	13	13	2	19	33	59	84
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	76.59	65.27	94.89	17.25	155.49	192.14	0.0	0.0
MEDIUM DENSITY RESIDENTIAL	2.42	0.0	19.85	1.00	3.56	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	10.30	0.0	0.0	0.0	0.0	0.0	67.90	135.89
COMMERCIAL	3.96	2.26	0.33	0.50	2.29	2.08	10.49	0.0
INSTITUTIONAL	1.56	9.15	10.52	0.41	9.42	20.06	0.0	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	843	844	845	851	852	861	862	863
POPULATION PER ZONE	44	2	0	40	17	11	12	16
DWELLINGS PER ZONE	11	1	0	9	5	2	5	6
CARS PER ZONE	14	1	0	10	7	2	4	7
LABOUR FORCE PER ZONE	8	0	0	3	6	2	6	5
EMPLOYMENT PER ZONE	866	223	131	394	700	102	335	663
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR PRODUCTION	6	0	0	1	3	2	1	2
PEAK HOUR CHOICE PRODUCTION	6	0	0	0	3	2	1	1
PEAK HOUR CAPTIVE PRODUCTION	0	0	0	1	0	0	0	1
			(peak hour vehicular work trips only)					
TOTAL PEAK HOUR ATTRACTION	593	131	85	288	496	57	230	468
PEAK HOUR CHOICE ATTRACTION	544	114	79	268	447	55	209	429
PEAK HOUR CAPTIVE ATTRACTION	49	17	6	20	49	2	21	39
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14
MEDIUM DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH DENSITY RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIVERSITY-COLLEGE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	141.06	20.69	157.70	53.80	95.68	44.40	23.99	186.81
COMMERCIAL	0.0	10.14	12.24	0.0	0.0	9.84	0.0	0.0
INSTITUTIONAL	0.0	3.38	0.0	2.25	33.15	0.0	0.0	0.0

TABLE A.1 (CONTINUED)

DEMOGRAPHIC, TRIP END AND LAND USE DATA FOR EDMONTON (1971) AS USED IN TRIP GENERATION ANALYSES

TRAFFIC ZONE	891	892						TOTAL
POPULATION PER ZONE	5	49						428974
DWELLINGS PER ZONE	2	13						131208
CARS PER ZONE	2	4						143822
LABOUR FORCE PER ZONE	1	5						154770
EMPLOYMENT PER ZONE	62	358						144526
TOTAL PEAK HOUR PRODUCTION	0	4	(peak hour vehicular work trips only)					75391
PEAK HOUR CHOICE PRODUCTION	0	3						57016
PEAK HOUR CAPTIVE PRODUCTION	0	1						18375
TOTAL PEAK HOUR ATTRACTION	26	226	(peak hour vehicular work trips only)					70761
PEAK HOUR CHOICE ATTRACTION	24	198						52586
PEAK HOUR CAPTIVE ATTRACTION	2	28						18175
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
LOW DENSITY RESIDENTIAL	0.52	100.99						13102.11
MEDIUM DENSITY RESIDENTIAL	0.0	0.0						1418.37
HIGH DENSITY RESIDENTIAL	0.0	0.0						519.22
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
CENTRAL AREA OFFICE	0.0	0.0						107.88
UNIVERSITY-COLLEGE	0.0	0.0						202.91
INDUSTRIAL	15.12	69.46						3098.67
COMMERCIAL	10.31	0.0						861.16
INSTITUTIONAL	0.0	0.0						2229.52

APPENDIX B

RECALIBRATION OF TRIP PRODUCTION MODELS TO DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961 : COMPARISON OF RESULTS

TABLE B.1

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR PRODUCTIONS		ACTUAL TOTAL TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 1		MODEL 2	
	MODEL 1	MODEL 2		TRIPS	%	TRIPS	%
45	668	619	674	-6	0	-55	-8
53	652	615	533	119	22	82	15
56	332	290	396	-64	-16	-106	-26
62	1156	1250	1710	-554	-32	-460	-26
71	866	1071	977	-111	-11	94	9
72	435	357	212	223	105	145	68
84	718	697	676	42	6	21	3
85	810	785	730	80	10	55	7
86	613	590	570	43	7	20	3
91	763	725	734	29	3	-9	-1
92	620	590	580	40	6	10	1
101	687	605	296	391	132	309	104
104	326	417	582	-256	-43	-165	-28
105	506	678	309	197	63	369	119
106	298	301	159	139	87	142	89
112	643	643	581	62	10	62	10
113	372	346	303	69	22	43	14
116	318	281	179	139	77	102	56
126	788	791	791	-3	0	0	0
132	635	636	710	-75	-10	-74	-10
134	491	478	517	-26	-5	-39	-7
212	883	884	828	55	6	56	6
273	400	365	431	-31	-7	-66	-15
274	536	500	609	-73	-11	-109	-17
281	867	858	640	227	35	218	34
282	268	231	203	65	32	28	13
283	470	441	463	7	1	-22	-4
321	432	413	505	-73	-14	-92	-18
323	505	484	519	-14	-2	-35	-6
324	401	379	346	55	15	33	9

TABLE B.1 (CONTINUED)

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR PRODUCTIONS		ACTUAL TOTAL TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 1		MODEL 2	
	MODEL 1	MODEL 2		TRIPS	%	TRIPS	%
332	728	715	842	-114	-13	-127	-15
333	568	533	477	91	19	56	11
411	666	660	641	25	3	19	2
412	559	532	594	-35	-5	-62	-10
423	702	687	622	80	12	65	10
424	409	390	345	64	18	45	13
431	287	241	216	71	32	25	11
432	687	786	978	-291	-29	-192	-19
433	423	393	434	-11	-2	-41	-9
434	452	458	516	-64	-12	-58	-11
442	753	1032	1213	-460	-37	-181	-14
455	463	641	490	-27	-5	151	30
461	433	404	426	7	1	-22	-5
462	560	548	602	-42	-6	-54	-8
463	580	579	547	33	6	32	5
464	720	746	697	23	3	49	7
471	502	486	616	-114	-18	-130	-21
472	420	401	389	31	7	12	3
474	471	448	419	52	12	29	6
475	494	472	419	75	17	53	12
479	333	266	230	103	44	36	15
492	463	441	372	91	24	69	18
493	547	521	458	89	19	63	13
496	742	729	698	44	6	31	4
501	784	807	792	-8	-1	15	1
503	366	341	356	10	2	-15	-4
602	498	488	217	281	129	271	124
605	489	603	241	248	102	362	150
611	777	786	674	103	15	112	16
681	625	663	635	-10	-1	28	4

TABLE B.1 (CONTINUED)

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR PRODUCTIONS		ACTUAL TOTAL TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 1		MODEL 2	
	MODEL 1	MODEL 2		TRIPS	%	TRIPS	%
691	615	639	520	95	18	119	22
692	915	901	900	15	1	1	0
693	554	539	646	-92	-14	-107	-16
694	392	370	409	-17	-4	-39	-9
695	277	238	223	54	24	15	6
702	750	821	872	-122	-13	-51	-5
703	736	792	751	-15	-1	41	5
704	461	521	723	-262	-36	-202	-27
722	497	483	374	123	32	109	29
723	421	398	562	-141	-25	-164	-29
725	463	431	497	-34	-6	-66	-13
732	703	666	674	29	4	-8	-1
733	1143	1188	931	212	22	257	27
743	474	454	559	-85	-15	-105	-18
744	306	272	365	-59	-16	-93	-25
746	269	232	204	65	31	28	13
747	302	303	397	-95	-23	-94	-23
751	611	615	704	-93	-13	-89	-12
753	385	363	421	-36	-8	-58	-13
754	578	575	690	-112	-16	-115	-16
755	648	630	659	-11	-1	-29	-4
781	542	530	659	-117	-17	-129	-19
821	361	353	432	-71	-16	-79	-18
822	380	353	367	13	3	-14	-3
823	320	290	292	28	9	-2	0
824	606	574	611	-5	0	-37	-6
832	654	656	762	-108	-14	-106	-13
833	742	760	937	-195	-20	-177	-18
TOTALS	49065	49064	49060	8269	16	7760	15

TABLE B.2

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE PRODUCTIONS		ACTUAL CHOICE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 3		MODEL 4	
	MODEL 3	MODEL 4		TRIPS	%	TRIPS	%
45	457	420	392	65	16	28	7
53	461	434	381	80	20	53	13
56	233	211	302	-69	-22	-91	-30
62	742	777	1011	-269	-26	-234	-23
71	535	641	569	-34	-5	72	12
72	257	204	92	165	179	112	121
84	525	509	483	42	8	26	5
85	584	563	517	67	12	46	8
86	449	435	395	54	13	40	10
91	535	504	445	90	20	59	13
92	447	427	375	72	19	52	13
101	407	342	141	266	188	201	142
104	204	261	377	-173	-45	-116	-30
105	327	433	169	158	93	264	156
106	208	218	94	114	121	124	131
112	501	505	428	73	17	77	17
113	281	271	228	53	23	43	18
116	231	214	139	92	66	75	53
126	604	606	572	32	5	34	5
132	497	502	529	-32	-6	-27	-5
134	379	377	375	4	1	2	0
212	668	666	662	6	0	4	0
273	290	272	328	-38	-11	-56	-17
274	382	360	441	-59	-13	-81	-18
281	643	633	518	125	24	115	22
282	195	179	150	45	30	29	19
283	345	330	332	13	3	-2	0
321	331	326	411	-80	-19	-85	-20
323	379	370	386	-7	-1	-16	-4
324	307	299	252	55	21	47	18

TABLE B.2 (CONTINUED)

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE PRODUCTIONS		ACTUAL CHOICE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 3		MODEL 4	
	MODEL 3	MODEL 4		TRIPS	%	TRIPS	%
332	543	533	653	-110	-16	-120	-18
333	405	383	383	22	5	0	0
411	509	508	522	-13	-2	-14	-2
412	408	392	434	-26	-5	-42	-9
423	522	512	503	19	3	9	1
424	315	310	247	68	27	63	25
431	197	173	168	29	17	5	2
432	483	549	628	-145	-23	-79	-12
433	312	298	314	-2	0	-16	-5
434	320	329	337	-17	-5	-8	-2
442	487	655	780	-293	-37	-125	-16
455	290	399	356	-66	-18	43	12
461	320	306	355	-35	-9	-49	-13
462	429	425	501	-72	-14	-76	-15
463	457	462	424	33	7	38	8
464	567	589	536	31	5	53	9
471	383	378	486	-103	-21	-108	-22
472	324	319	297	27	9	22	7
474	353	344	359	-6	-1	-15	-4
475	368	359	322	46	14	37	11
479	202	160	152	50	32	8	5
492	349	340	274	75	27	66	24
493	402	387	347	55	15	40	11
496	553	544	538	15	2	6	1
501	626	645	647	-21	-3	-2	0
503	279	271	298	-19	-6	-27	-9
602	389	389	197	192	97	192	97
605	330	408	187	143	76	221	118
611	604	612	520	84	16	92	17
681	478	510	491	-13	-2	19	3

TABLE B.2 (CONTINUED)

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE PRODUCTIONS		ACTUAL CHOICE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 3		MODEL 4	
	MODEL 3	MODEL 4		TRIPS	%	TRIPS	%
691	476	498	402	74	18	96	23
692	600	576	593	7	1	-17	-2
693	420	414	488	-68	-13	-74	-15
694	301	294	311	-10	-3	-17	-5
695	200	183	185	15	8	-2	-1
702	457	483	589	-132	-22	-106	-17
703	451	470	476	-25	-5	-6	-1
704	326	372	434	-108	-24	-62	-14
722	383	380	273	110	40	107	39
723	319	310	409	-90	-22	-99	-24
725	337	319	375	-38	-10	-56	-14
732	495	466	477	18	3	-11	-2
733	901	927	748	153	20	179	23
743	360	353	436	-76	-17	-83	-19
744	226	212	258	-32	-12	-46	-17
746	196	181	153	43	28	28	18
747	212	221	296	-84	-28	-75	-25
751	483	490	593	-110	-18	-103	-17
753	295	288	349	-54	-15	-61	-17
754	452	456	574	-122	-21	-118	-20
755	482	471	561	-79	-14	-90	-16
781	416	413	531	-115	-21	-118	-22
821	267	270	272	-5	-1	-2	0
822	286	275	272	14	5	3	1
823	241	230	234	7	2	-4	-1
824	435	413	490	-55	-11	-77	-15
832	511	516	571	-60	-10	-55	-9
833	592	607	768	-176	-22	-161	-20
TOTALS	35728	35866	35868	6142	17	5662	15

TABLE B.3

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE PRODUCTIONS		ACTUAL CAPTIVE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 5		MODEL 6	
	MODEL 5	MODEL 6		TRIPS	%	TRIPS	%
45	211	199	282	-71	-25	-83	-29
53	191	181	152	39	25	29	19
56	99	78	94	5	5	-16	-17
62	414	474	699	-285	-40	-225	-32
71	331	429	408	-77	-18	21	5
72	178	153	120	58	48	33	27
84	193	187	193	0	0	-6	-3
85	226	222	213	13	6	9	4
86	164	155	175	-11	-6	-20	-11
91	228	221	289	-61	-21	-68	-23
92	173	163	205	-32	-15	-42	-20
101	279	263	155	124	80	108	69
104	122	155	205	-83	-40	-50	-24
105	180	245	140	40	28	105	75
106	90	83	65	25	38	18	27
112	142	138	153	-11	-7	-15	-9
113	91	75	75	16	21	0	0
116	87	67	40	47	117	27	67
126	184	184	219	-35	-15	-35	-15
132	138	135	181	-43	-23	-46	-25
134	112	101	142	-30	-21	-41	-28
212	215	218	166	49	29	52	31
273	110	93	103	7	6	-10	-9
274	154	140	168	-14	-8	-28	-16
281	224	225	122	102	83	103	84
282	73	51	53	20	37	-2	-3
283	125	111	131	-6	-4	-20	-15
321	100	87	94	6	6	-7	-7
323	126	114	133	-7	-5	-19	-14
324	95	80	94	1	1	-14	-14

TABLE B.3 (CONTINUED)

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE PRODUCTIONS		ACTUAL CAPTIVE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 5		MODEL 6	
	MODEL 5	MODEL 6		TRIPS	%	TRIPS	%
332	186	182	189	-3	-1	-7	-3
333	163	150	94	69	73	56	59
411	157	152	119	38	31	33	27
412	151	140	160	-9	-5	-20	-12
423	180	175	119	61	51	56	47
424	94	80	98	-4	-4	-18	-18
431	90	67	48	42	87	19	39
432	204	237	350	-146	-41	-113	-32
433	111	95	120	-9	-7	-25	-20
434	131	129	179	-48	-26	-50	-27
442	266	376	433	-167	-38	-57	-13
455	172	243	134	38	28	109	81
461	113	98	71	42	59	27	38
462	131	123	101	30	29	22	21
463	123	117	123	0	0	-6	-4
464	152	156	161	-9	-5	-5	-3
471	118	107	130	-12	-9	-23	-17
472	96	82	92	4	4	-10	-10
474	117	104	60	57	95	44	73
475	126	114	97	29	29	17	17
479	131	106	78	53	67	28	35
492	114	101	98	16	16	3	3
493	146	134	111	35	31	23	20
496	189	185	160	29	18	25	15
501	158	162	145	13	8	17	11
503	87	70	58	29	50	12	20
602	109	99	20	89	445	79	395
605	158	196	54	104	192	142	262
611	172	174	154	18	11	20	12
681	147	153	144	3	2	9	6

TABLE B.3 (CONTINUED)

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP PRODUCTION MODELS TO ZONES DEVELOPED PRIOR TO 1961

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE PRODUCTIONS		ACTUAL CAPTIVE TRIP PRODUCTIONS	CALIBRATION ERROR			
				MODEL 5		MODEL 6	
	MODEL 5	MODEL 6		TRIPS	%	TRIPS	%
691	140	141	118	22	18	23	19
692	314	324	307	7	2	17	5
693	134	125	158	-24	-15	-33	-20
694	91	76	98	-7	-7	-22	-22
695	76	55	38	38	100	17	44
702	293	337	283	10	3	54	19
703	285	322	275	10	3	47	17
704	135	149	289	-154	-53	-140	-48
722	114	103	101	13	12	2	1
723	103	88	153	-50	-32	-65	-42
725	127	112	122	5	4	-10	-8
732	208	199	197	11	5	2	1
733	242	261	183	59	32	78	42
743	114	102	123	-9	-7	-21	-17
744	80	60	107	-27	-25	-47	-43
746	72	51	51	21	41	0	0
747	90	82	101	-11	-10	-19	-18
751	128	124	111	17	15	13	11
753	90	74	72	18	25	2	2
754	126	119	116	10	8	3	2
755	166	159	98	68	69	61	62
781	126	117	128	-2	-1	-11	-8
821	94	82	160	-66	-41	-78	-48
822	94	78	95	-1	-1	-17	-17
823	79	60	58	21	36	2	3
824	172	161	121	51	42	40	33
832	144	140	191	-47	-24	-51	-26
833	151	153	169	-18	-10	-16	-9
TOTALS	13335	13188	13192	3321	25	3218	24

APPENDIX C

RECALIBRATION OF TRIP ATTRACTION MODELS TO DATA CORRESPONDING TO ZONES DEVELOPED PRIOR TO 1961 : COMPARISON OF RESULTS

TABLE C.1

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR ATTRACTIONS		ACTUAL TOTAL TRIP ATTRACT-IONS	CALIBRATION ERROR			
				MODEL 7		MODEL 8	
	MODEL 7	MODEL 8		TRIPS	%	TRIPS	%
12	1595	2020	1865	-270	-14	155	8
13	2237	2871	2110	127	6	761	36
14	3441	4482	2906	535	18	1576	54
22	406	419	415	-9	-2	4	0
31	1911	2413	4010	-2099	-52	-1597	-39
32	3027	3876	5410	-2383	-44	-1534	-28
44	232	174	210	22	10	-36	-17
45	230	165	203	27	13	-38	-18
46	260	187	70	190	271	117	167
51	432	456	494	-62	-12	-38	-7
52	1875	1575	1570	305	19	5	0
53	521	461	576	-55	-9	-115	-19
54	319	240	128	191	149	112	87
55	386	447	638	-252	-39	-191	-29
56	382	308	293	89	30	15	5
61	321	337	695	-374	-53	-358	-51
62	332	267	473	-141	-29	-206	-43
63	260	230	144	116	80	86	59
64	302	303	698	-396	-56	-395	-56
72	400	344	899	-499	-55	-555	-61
73	307	313	535	-228	-42	-222	-41
81	301	302	183	118	64	119	65
82	309	315	206	103	50	109	52
84	280	207	176	104	59	31	17
85	288	227	216	72	33	11	5
86	318	253	152	166	109	101	66
87	454	559	407	47	11	152	37
91	332	264	254	78	30	10	3
92	266	204	323	-57	-17	-119	-36
101	285	230	279	6	2	-49	-17

TABLE C.1 (CONTINUED)

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR ATTRACTIONS		ACTUAL TOTAL TRIP ATTRACT- IONS	CALIBRATION ERROR			
				MODEL 7		MODEL 8	
	MODEL 7	MODEL 8		TRIPS	%	TRIPS	%
102	234	165	110	124	112	55	50
103	278	262	520	-242	-46	-258	-49
105	310	244	201	109	54	43	21
112	272	215	90	182	202	125	138
122	418	495	461	-43	-9	34	7
123	247	210	304	-57	-18	-94	-30
126	286	227	73	213	291	154	210
132	303	232	117	186	158	115	98
212	380	379	159	221	138	220	138
273	356	290	112	244	217	178	158
274	286	217	99	187	188	118	119
281	424	359	394	30	7	-35	-8
283	316	244	114	202	177	130	114
284	306	312	573	-267	-46	-261	-45
403	820	1186	1471	-651	-44	-285	-19
404	370	412	234	136	58	178	76
405	890	1305	1360	-470	-34	-55	-4
406	590	605	321	269	83	284	88
411	279	219	106	173	163	113	106
412	237	175	307	-70	-22	-132	-42
421	320	330	168	152	90	162	96
422	254	221	143	111	77	78	54
424	302	247	268	34	12	-21	-7
431	264	212	162	102	62	50	30
432	266	198	91	175	192	107	117
433	213	148	108	105	97	40	37
434	292	217	308	-16	-5	-91	-29
443	232	162	196	36	18	-34	-17
444	239	169	312	-73	-23	-143	-45
451	264	190	189	75	39	1	0

TABLE C.1 (CONTINUED)

CALIBRATION OF TOTAL PEAK HOUR VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF TOTAL PEAK HOUR ATTRACTIONS		ACTUAL TOTAL TRIP ATTRACTIONS	CALIBRATION ERROR			
				MODEL 7		MODEL 8	
	MODEL 7	MODEL 8		TRIPS	%	TRIPS	%
452	292	286	172	120	69	114	66
453	273	199	483	-210	-43	-284	-58
454	341	324	424	-83	-19	-100	-23
461	318	266	115	203	176	151	131
463	251	185	107	144	134	78	72
464	254	195	83	171	206	112	134
478	405	320	106	299	282	214	201
479	355	277	183	172	93	94	51
496	294	225	88	206	234	137	155
603	8467	7254	7237	1230	16	17	0
605	253	184	228	25	10	-44	-19
611	237	179	129	108	83	50	38
692	398	328	369	29	7	-41	-11
695	226	169	144	82	56	25	17
702	388	317	568	-180	-31	-251	-44
703	287	222	182	105	57	40	21
711	469	416	392	77	19	24	6
712	365	377	374	-9	-2	3	0
713	299	287	180	119	66	107	59
714	600	817	325	275	84	492	151
723	251	184	83	168	202	101	121
725	256	191	86	170	197	105	122
754	237	175	137	100	72	38	27
822	285	238	255	30	11	-17	-6
823	246	182	79	167	211	103	130
832	247	183	91	156	171	92	101
833	264	207	223	41	18	-16	-7
841	542	622	683	-141	-20	-61	-8
842	645	895	868	-223	-25	27	3
TOTALS	50002	50000	50003	19119	38	15349	30

TABLE C.2

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE ATTRACTIONS		ACTUAL CHOICE TRIP ATTRACT-IONS	CALIBRATION ERROR			
				MODEL 9		MODEL 10	
	MODEL 9	MODEL 10		TRIPS	%	TRIPS	%
12	1064	1309	1176	-112	-9	133	11
13	1471	1843	1424	47	3	419	29
14	2234	2844	1768	466	26	1076	60
22	311	301	302	9	2	-1	0
31	1264	1549	2837	-1573	-55	-1288	-45
32	1971	2463	3330	-1359	-40	-867	-26
44	201	134	180	21	11	-46	-25
45	200	128	177	23	12	-49	-27
46	219	148	47	172	365	101	214
51	327	362	415	-88	-21	-53	-12
52	1242	1012	1100	142	12	-88	-8
53	384	379	438	-54	-12	-59	-13
54	256	193	95	161	169	98	103
55	298	378	530	-232	-43	-152	-28
56	296	250	214	82	38	36	16
61	257	281	524	-267	-50	-243	-46
62	264	214	376	-112	-29	-162	-43
63	218	186	125	93	74	61	48
64	245	252	617	-372	-60	-365	-59
72	307	283	717	-410	-57	-434	-60
73	248	260	428	-180	-42	-168	-39
81	244	251	161	83	51	90	55
82	249	262	183	66	36	79	43
84	231	165	144	87	60	21	14
85	236	181	165	71	43	16	9
86	255	204	120	135	112	84	70
87	341	475	343	-2	0	132	38
91	264	211	209	55	26	2	0
92	223	162	252	-29	-11	-90	-35
101	234	184	232	2	0	-48	-20

TABLE C.2 (CONTINUED)

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE ATTRACTIONS		ACTUAL CHOICE TRIP ATTRACTIONS	CALIBRATION ERROR			
				MODEL 9		MODEL 10	
	MODEL 9	MODEL 10		TRIPS	%	TRIPS	%
102	202	129	87	115	132	42	48
103	230	215	312	-82	-26	-97	-31
105	250	196	143	107	74	53	37
112	226	169	76	150	197	93	122
122	318	421	417	-99	-23	4	0
123	211	170	249	-38	-15	-79	-31
126	235	179	57	178	312	122	214
132	246	185	99	147	148	86	86
212	295	309	125	170	136	184	147
273	280	233	95	185	194	138	145
274	235	173	81	154	190	92	113
281	323	292	330	-7	-2	-38	-11
283	254	195	94	160	170	101	107
284	248	259	492	-244	-49	-233	-47
403	573	1029	1258	-685	-54	-229	-18
404	288	345	194	94	48	151	77
405	618	1133	1153	-535	-46	-20	-1
406	427	512	295	132	44	217	73
411	231	172	80	151	188	92	115
412	204	136	171	33	19	-35	-20
421	256	275	156	100	64	119	76
422	215	179	126	89	70	53	42
424	245	197	222	23	10	-25	-11
431	221	165	113	108	95	52	46
432	222	156	75	147	196	81	108
433	189	113	85	104	122	28	32
434	239	173	259	-20	-7	-86	-33
443	201	126	140	61	43	-14	-10
444	205	132	224	-19	-8	-92	-41
451	221	151	152	69	45	-1	0

TABLE C.2 (CONTINUED)

CALIBRATION OF PEAK HOUR CHOICE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CHOICE ATTRACTIONS		ACTUAL CHOICE TRIP ATTRACT-IONS	CALIBRATION ERROR			
				MODEL 9		MODEL 10	
	MODEL 9	MODEL 10		TRIPS	%	TRIPS	%
452	239	236	122	117	95	114	93
453	227	158	357	-130	-36	-199	-55
454	270	229	259	11	4	-30	-11
461	255	211	94	161	171	117	124
463	213	145	95	118	124	50	52
464	215	152	73	142	194	79	108
478	310	262	100	210	210	162	162
479	279	224	152	127	83	72	47
496	240	179	67	173	258	112	167
603	5417	4596	4568	849	18	28	0
605	214	144	160	54	33	-16	-10
611	204	138	100	104	104	38	38
692	306	266	311	-5	-1	-45	-14
695	197	132	125	72	57	7	5
702	299	259	451	-152	-33	-192	-42
703	236	177	152	84	55	25	16
711	351	346	332	19	5	14	4
712	285	316	314	-29	-9	2	0
713	243	234	170	73	42	64	37
714	434	704	277	157	56	427	154
723	213	144	59	154	261	85	144
725	216	150	71	145	204	79	111
754	204	136	120	84	70	16	13
822	234	192	211	23	10	-19	-9
823	210	142	66	144	218	76	115
832	210	143	72	138	191	71	98
833	221	162	190	31	16	-28	-14
841	397	531	624	-227	-36	-93	-14
842	463	773	784	-321	-40	-11	-1
TOTALS	36464	36464	36465	14765	40	11389	31

TABLE C.3

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE ATTRACTIONS		ACTUAL CAPTIVE TRIP ATTRACT-IONS	CALIBRATION ERROR			
				MODEL 11		MODEL 12	
	MODEL 11	MODEL 12		TRIPS	%	TRIPS	%
12	531	711	689	-158	-22	22	3
13	766	1029	686	80	11	343	50
14	1208	1638	1138	70	6	500	43
22	95	118	113	-18	-15	5	4
31	647	864	1173	-526	-44	-309	-26
32	1056	1414	2080	-1024	-49	-666	-32
44	31	40	30	1	3	10	33
45	31	37	26	5	19	11	42
46	42	39	23	19	82	16	69
51	104	94	79	25	31	15	18
52	634	563	470	164	34	93	19
53	137	82	138	-1	0	-56	-40
54	63	47	33	30	90	14	42
55	88	69	108	-20	-18	-39	-36
56	86	58	79	7	8	-21	-26
61	64	56	171	-107	-62	-115	-67
62	68	53	97	-29	-29	-44	-45
63	41	44	19	22	115	25	131
64	57	52	81	-24	-29	-29	-35
72	93	61	182	-89	-48	-121	-66
73	59	53	107	-48	-44	-54	-50
81	56	52	22	34	154	30	136
82	59	53	23	36	156	30	130
84	49	42	32	17	53	10	31
85	52	46	51	1	1	-5	-9
86	63	49	32	31	96	17	53
87	113	84	64	49	76	20	31
91	68	52	45	23	51	7	15
92	44	42	71	-27	-38	-29	-40
101	51	46	47	4	8	-1	-2

TABLE C.3 (CONTINUED)

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE ATTRACTIONS		ACTUAL CAPTIVE TRIP ATTRACTIONS	CALIBRATION ERROR			
				MODEL 11		MODEL 12	
	MODEL 11	MODEL 12		TRIPS	%	TRIPS	%
102	32	37	23	9	39	14	60
103	48	47	208	-160	-76	-161	-77
105	60	48	58	2	3	-10	-17
112	46	47	14	32	228	33	235
122	99	75	44	55	125	31	70
123	37	41	55	-18	-32	-14	-25
126	51	48	16	35	218	32	200
132	57	47	18	39	216	29	161
212	86	71	34	52	152	37	108
273	77	57	17	60	352	40	235
274	51	44	18	33	183	26	144
281	102	68	64	38	59	4	6
283	62	48	20	42	210	28	140
284	58	53	81	-23	-28	-28	-34
403	247	156	213	34	15	-57	-26
404	82	68	40	42	105	28	70
405	273	173	207	66	31	-34	-16
406	162	93	26	136	523	67	257
411	48	46	26	22	84	20	76
412	33	39	136	-103	-75	-97	-71
421	63	55	12	51	425	43	358
422	39	42	17	22	129	25	147
424	57	49	46	11	23	3	6
431	43	47	49	-6	-12	-2	-4
432	44	42	16	28	175	26	162
433	24	34	23	1	4	11	47
434	53	44	49	4	8	-5	-10
443	31	36	56	-25	-44	-20	-35
444	34	37	88	-54	-61	-51	-57
451	43	40	37	6	16	3	8

TABLE C.3 (CONTINUED)

CALIBRATION OF PEAK HOUR CAPTIVE VEHICULAR WORK TRIP ATTRACTION MODELS

ZONE NUMBER	CALIBRATION OF PEAK HOUR CAPTIVE ATTRACTIONS		ACTUAL CAPTIVE TRIP ATTRACTIONS	CALIBRATION ERROR			
				MODEL 11		MODEL 12	
	MODEL 11	MODEL 12		TRIPS	%	TRIPS	%
452	53	50	50	3	6	0	0
453	46	41	126	-80	-63	-85	-67
454	71	95	165	-94	-56	-70	-42
461	63	55	21	42	200	34	161
463	38	40	12	26	216	28	233
464	39	43	10	29	290	33	330
478	95	58	6	89	1483	52	866
479	76	53	31	45	145	22	70
496	54	46	21	33	157	25	119
603	3050	2658	2669	381	14	-11	0
605	39	39	68	-29	-42	-29	-42
611	33	41	29	4	13	12	41
692	92	62	58	34	58	4	6
695	29	37	19	10	52	18	94
702	88	58	117	-29	-24	-59	-50
703	51	45	30	21	70	15	50
711	118	70	60	58	96	10	16
712	80	62	60	20	33	2	3
713	56	53	10	46	460	43	430
714	166	112	48	118	245	64	133
723	38	40	24	14	58	16	66
725	40	41	15	25	166	26	173
754	33	39	17	16	94	22	129
822	51	45	44	7	15	1	2
823	36	40	13	23	176	27	207
832	37	40	19	18	94	21	110
833	43	45	33	10	30	12	36
841	145	92	59	86	145	33	55
842	183	122	84	99	117	38	45
TOTALS	13541	13542	13538	5387	39	4448	32